An exploration of residents' and care partners' perspective on 3D printed pureed food in long-term care homes in Ontario.

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be electronically available to the public.

Abstract

Introduction: Dysphagia, or swallowing difficulties, results in the inability to consume foods of regular texture and/or fluids of regular consistency. A large proportion of residents in long term-care (LTC) homes in Ontario suffer from dysphagia and as a consequence receive texture modified foods such as pureed food. Some evidence suggests that the necessity to consume pureed food could negatively impact residents' health outcomes and quality of life. This may be due to the poor sensory properties and inconsistent quality of these foods. This study explores the potential of a novel food development, namely 3D printed pureed food (3DPPF), in overcoming some of the issues associated with traditional pureed food in LTC homes. The aim is to explore how Ontario's LTC residents and their care partners perceive the potential for 3DPPF in LTC homes.

Methods: This study uses a qualitative methodology and an interpretive description strategy in guiding its purpose, design, and analysis with the aim of formulating results that are useful and transferable to practice in LTC homes. A total of 39 participants were recruited for semi-structured interviews and discussion groups to explore the perspectives of three groups of stakeholders about the potential of 3DPPF in LTC homes in Ontario. The three groups included: registered dietitians (RDs), dietary team members, and residents and family members. An interpretive description approach with an inductive thematic analysis strategy was used to analyze the data generated from this study.

Results: Themes from this study provide an understanding on the perspectives of residents, family members, RDs, and dietary team members on 3DPPF as an alternative to current types of pureed food offered in LTC. Overall, participants shared that this novel development could help improve residents' dining experience, intake, and quality of life. They described that skills, context,

resources, quality, and transparency should be carefully evaluated to ensure that 3DPPF fits within the LTC context. Details about participants' perspectives are described in Parts 1-3.

In part 1, three main themes represented RDs' perspectives: weighing the risks against the benefits of a pureed diet with residents and families; using 3D printing to market pureed food more positively to residents, families, and team members; and finding solutions that are workable.

In part 2, residents and family members offered their perspectives on 3DPPF and two themes emerged from their accounts: ensuring that the residents are happy with the food; and appreciating novelty while acknowledging potential limitations.

In part 3, three overarching themes were uncovered from interviews with dietary team members: producing pureed food is challenging; fitting 3DPPF into the LTC context; and zooming in on quality.

Discussion: Overall, participants were motivated to improve the quality of pureed food offered in LTC and 3DPPF was thought to be a potentially effective solution in achieving this goal. However, concerns around capabilities of introducing this product in LTC were highlighted andparticipants described that transparency and training would improve the skills and confidence required for the introduction of 3DPPF in LTC. Additionally, environmental and contextual considerations were thought to influence uptake; environmental restructuring would be necessary to ensure equipment availability, applicability, cost efficiency, and compliance with LTC homes' standards and policies. All groups included in this study described the importance of quality assurance and of meeting requirements and expectations for taste, presentation, visual appeal, texture, variety, nutritional value, and safety. Themes also demonstrate that the collaboration of various social actors would be needed to ensure that the product is workable and acceptable in LTC. As such,

taste testing with residents and families would be necessary to assess acceptability and potential of 3DPPF in LTC. A pilot phase would be required and it should involve residents, family members, care partners, and senior personnel; this type of collaboration would empower social actors to streamline implementation efforts of 3DPPF according to operational, procedural, and legislative requirements while offering a foundation for knowledge sharing.

Conclusion: This studydemonstrates that there is an evident need to improve the quality of pureed food in LTC and 3DPPF may be a desirable option to achieve this goal. These products should offer a competitive advantage and meet quality standards in order to be considered by LTC homes. Further testing and a piloting phase in a LTC setting would assist participants in determining if 3DPPF is a workable, acceptable, and effective solution. Finally, uptake and acceptability could be improved through enablement and incentivisation of social actors, education and training, and environmental restructuring.

Implications for research and practice: Learning from this study could help improve the quality of pureed food offered in LTC and will be translated to LTC homes, RDs, and industry partners. The results will also be disseminated to inform further research and development in the area of 3DPPF in general and in LTC in particular.

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I acknowledge the land on which I completed my degree is on traditional territory of the Neutral, Anishnawbe and Haudenosaunee peoples. The University of Waterloo is situated on the Haldimand tract, the land promised to the Six Nations that includes six miles on each side of the Grand River.

I am eternally indebted to my advisor, role model and mentor, Professor Heather Keller, who supported me and believed in my capabilities throughout this master's program. Her strive for excellence in research and practice inspired me to seek innovative research philosophies and methods as well as novel ways to improve residents' nutrition, health, and well-being.

Special thanks to my committee members, Professor Devries-Aboud and Professor Duizer for their support, collaboration and interest in reviewing this dissertation. Appreciation also goes to Professor Moresoli who proposed this project and exposed me to the 3D printer prototype, for the first time, in her lab.

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To the University of Waterloo, thank you for being supportive of students with mental and physical illnesses. I have experienced severe mental health issues during the course of my master's studies

which led me to contemplate quitting the program but the University offered me all the accommodations necessary to support me in pursuing my education and complete this thesis. This work would not have been possible without these accommodations and without the support ofmy family, my best friends, and Professor Keller.

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Table of Contents

List of Tables

Abbreviations

3DPPF – 3D Printed Pureed Food

COM-B – Capability, Opportunity, Motivation

DG – Discussion Group

K2A – Knowledge to Action

LTC – Long-Term-Care

MOHLTC – Ministry of Health and Long-Term-Care

RD – Registered Dietitian

SLP – Speech Language Pathologist

TDF – Theoretical Domains Framework

TMFs – Texture Modified Foods

Chapter 1: introduction and Overview

The proportion of older adults in Canada has been exponentially growing over the last decade and is expected to reach 23-25% of the population by 2036 (Statistics Canada, 2016). These changing demographics translate into an increased complexity of cognitive and physical impairment in the Canadian population necessitating long-term care (LTC) accommodations (Gibbard, 2017). More than half of LTC residents have some form of dementia which, when present, especially in advanced stages, has many detrimental effects on health and functional abilities (Canadian Institute for Health information, 2017). Both institutionalization and dementia are independent risk factors for weight loss and malnutrition in older adults (Moneira et al., 2016). Additionally, dementia is associated with oropharyngeal dysphagia, which is a modifiable risk factor for malnutrition and weight loss (Easterling & Robbins, 2008; Keller, & Bocock, 2011; Wirth et al., 2016; Alzheimer's Disease International, 2014; Tamura, Masaki, & Amella, 2013). Furthermore, if left without appropriate nutritional and clinical attention, dysphagia could lead to dehydration, aspiration pneumonia, and poor quality of life (Forster, Samaras, Gold, & Samaras, 2011).

Registered dietitians (RDs) and speech language pathologists (SLPs) are regulated health care professionals who conduct dysphagia assessments and provide recommendations and management strategies. A common recommendation for dysphagia management includes modification of diet texture and fluid consistency according to clinical indications and resident's needs and wishes (College of Dietitians of Ontario, 2018; Keller, Chambers, Niezgoda, & Duizer, 2012a). Some sources identified that 47% of all LTC home residents receive texture modified food while 10% receive specifically a pureed diet (Vucea, 2017a).

Unfortunately, older adults do not seem to enjoy pureed food, and issues with consistency, appearance, taste, and recognition of pureed food items have been expressed (Keller & Duizer, 2014b). These undesirable attributes of the traditional pureed food may lead to residents' refusal to consume these products which could potentially lead to malnutrition, weight loss, risk for aspiration or choking, and poor quality of life outcomes. This proposed thesis takes a qualitative interpretive approach in exploring residents' and care partners' perspectives on the potential of a novel food technology, namely 3D printed pureed food (3DPPF), in LTC homes in Ontario. The thesis is written in manuscript style with three chapters providing the results from this study. The following is an overview of these results chapters.

Part 1: Registered dietitians' perspectives on the potential for 3DPPF in LTC homes (Chapter 4)

Since Registered Dietitians (RDs) play an important role in the assessment, treatment, and monitoring of residents who require and/or receive pureed food, it was important to understand their perspectives on the potential for 3DPPF in the LTC context. A total of 10 RDs participated in this study and provided their input in Discussion Groups (DGs). The objective of the discussions was to understand the RDs' perceptions on benefits, limitations, opportunities, and barriers for the potential of 3DPPF in LTC. Each RD participated in one DG with no follow up and a total of four DGs were conducted to accommodate for RDs' availabilities. The following three themes emerged from the four DGs: weighing the risks against the benefits of pureed food with residents and families; using 3D printing to market pureed food more positively to residents, families, and team members; and finding solutions that are workable. Although it was initially expected that RDs would mainly focus on nutrition and health, they provided valuable input on applicability, workability, and product quality. They envisioned a potential for improving the quality of pureed

food, brainstormed possible limitations of the new technology, then problem solved some of the practical and operational issues that may arise should these products be available to LTC homes.

Part 2: Residents' and family members' perspectives on the potential for 3DPPF in LTC homes (Chapter 5)

Quality improvement projects in LTC rely heavily on residents' and family feedback; it was therefore of utmost importance to conduct interviews with this participant group. A total of 8 residents and 2 family members participated in individual interviews. The researcher sought their perspectives on the potential for 3DPPF as an alternative to current types of pureed food. Two major themes were identified from the interviews: ensuring that the residents are happy with the food; and, appreciating novelty while acknowledging potential limitations. Residents and families expressed some of their concerns with the traditional pureed food and voiced a need for improving its quality. On the other hand, they acknowledged that dietary team members likely have a heavy workload and conveyed that solutions must be practical and realistic.

Part 3: Dietary team members' perspectives on the potential for 3DPPF in LTC homes (Chapter 6)

Since the dietary department is substantially impacted by any dietary changes made in LTC, its members' voices and input are required to help inform effective interventions and quality improvement initiatives. This work captured the perspectives of cooks, dietary aides, and dietary managers on the practicality, feasibility, usefulness, implications, barriers, and potential benefits of 3DPPF in LTC. A total of 17 interviews were conducted with dietary team members from the five sites included in this study. Three major themes emerged from the interviews: producing pureed food is challenging, fitting 3DPPF into the LTC context, and zooming in on quality. The

qualitative data generated from dietary team members' interviews was very comprehensive and included clinical, operational, quality, and systematic considerations.

1.1 Reflexive standpoint

In this study, I used an interpretive approach which allowed me to gain insight and in-depth information about residents', team members', and dietitians' perspectives on 3DPPF in LTC (Thanh, N.C. & Thanh, T.T., 2015). My dissertation methodology was selected based on the overall objective of generating knowledge that is relevant and transferable to the LTC context.

I am a female researcher with a background in nutrition and dietetics, public health, and knowledge translation. My professional designation of registered dietitian (RD) and my experience as a RD in LTC facilitated the use of an interpretive description approach to conduct this study as this research method requires "sufficient grounding in the discipline to be able to discern its scope and boundaries" (Thorne, 2008, p. 67). My work experience as a RD in LTC allowed me to identify the problem both from a research and practical standpoint. Additionally, my knowledge about policy, procedures, protocols, and professional commitment allowed me to focus my inquiry process according to contextual considerations. My dissertation began with an independent exploration of the perspectives of each participant group and evolved with my recognition of the need to integrate all perspectives in order to gain a more comprehensive understanding about the potential for 3DPPF in LTC. Although the aim and scope of the study were not changed, I recognized that the perspective of other stakeholders, including nursing staff, senior management, and corporate personnel would be required in order to fully evaluate the feasibility of 3DPPF in LTC. Finally, while my roles of clinician and researcher played an important part in designing and

conducting this study, my passion for advocacy shaped my recommendations for further research and work in the area of 3DPPF for LTC residents.

1.2 Dissertation overview

This dissertation begins with a brief overview of the literature (Chapter 2) with a focus on describing the interest in improving the sensory and visual appeal of pureed food in LTC. An overview of interventions aimed at enhancing the appeal of pureed food, including their outcomes, considerations, and stakeholders' perspectives, is also provided. In chapter 3, the research questions and objectives of the project are outlined along with the general methodology used to conduct the study. Chapters 4-6 provide detailed description of methods and findings for each participant group included in this study as well as an introduction. These chapters have been written as manuscripts for publication. Chapter 7 provides a final discussion to connect all the chapters and offer a direction forward for research and practice.

Chapter 2: Literature Review

Dysphagia, or swallowing and/or chewing difficulties, is one of the major predictors of aspiration pneumonia for nursing home residents (Eisenstadt, 2010). Since aspiration pneumonia is a serious condition with the highest mortality rate of all nosocomial infections (Marrie et al. 2002, Shariatzadeh et al., 2006), it is essential to provide effective interventions to prevent health complications associated with dysphagia and aspiration. One common intervention used in LTC is the provision of modified texture diets for residents who experience difficulties chewing and/or swallowing foods of regular texture (College of Dietitians of Ontario, 2018; Keller, Chambers, Niezgoda, & Duizer, 2012a). One source cites that 47% of all LTC residents receive modified texture food and 10% receive pureed food (Vucea, 2017a). Unfortunately, these types of mechanically altered foods, and particularly pureed foods, are associated with an increased risk of malnutrition (Vucea et al., 2018) which may be explained by their poor sensory appeal (Blaise, 2009; Keller & Duizer, 2014b; Keller & Duizer, 2014c). Additionally, issues with consistency, acceptability, satisfaction, and quality of life have been reported (Ilhamto, Anciado, Keller, & Duizer, 2014; Cichero et al, 2017; Keller & Duizer 2014b; Martino, Beaton, & Diamant, 2009). It is therefore necessary to explore alternative ways to offer pureed food in order to improve its acceptability, consistency, and appeal with the aim of decreasing the risk of malnutrition while ensuring safety and improving residents' satisfaction and quality of life.

This literature review sheds light on current issues associated with pureed food in LTC by elaborating on multi-level determinants of food intake as described in the Making the Most of Mealtimes conceptual framework by Keller et al. (2014a), shown in fig 2.0. In this review, we present the available evidence about the effectiveness and acceptability of current types of pureed food, including molded and pre-shaped products using the core concepts of Meal Quality, Meal

Access, and Mealtime Experience to frame the evidence. We then describe a novel technology, namely 3D printed pureed food (3DPPF), and discuss its proposed potential in improving the quality of pureed food offered in LTC homes.

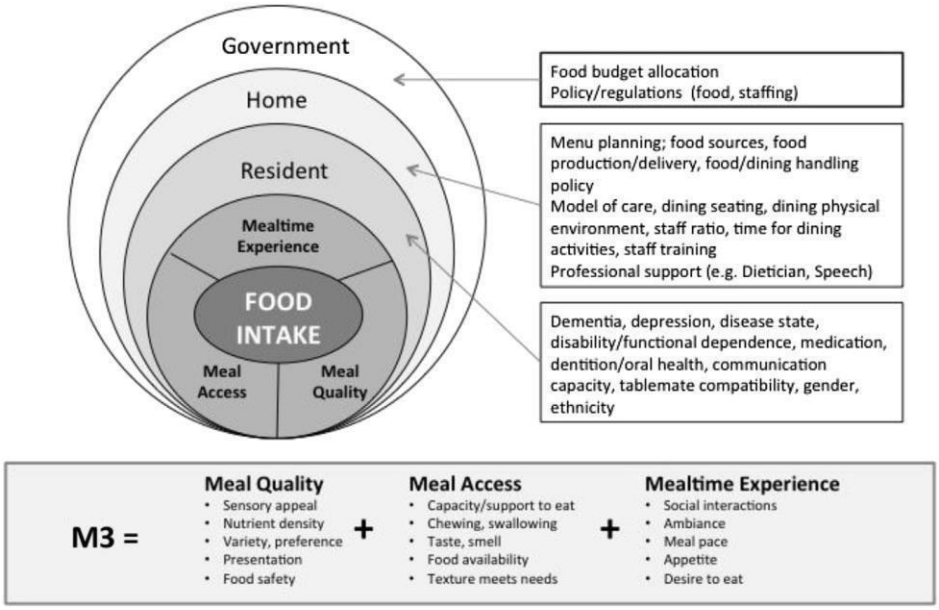


Figure 2.0 Making the Most of Mealtime Conceptual Framework

Adapted from Keller et al. (2014a)

2.1 Meal Quality: Visual Appeal, Mouthfeel and Taste of Pureed Food

Visual appeal, taste and mouthfeel are common concerns with pureed food. There has been growing interest in improving the visual appeal of pureed food in health care settings. Re-shaping texture modified foods (TMFs) through techniques such as molding and piping have been trialed in practice, but infrequently studied in research settings. Some qualitative studies revealed that cooks experience difficulties in retaining aroma and color of pureed food and use strategies such as food molds to improve the visual appeal (Murphy, Holmes, & Brooks 2017; Ilhamto et al., 2014). Others have investigated the effect of such techniques on resident's health outcomes. Germain, Dufresne, and Gray-Donald (2006) evaluated the effect of re-shaping TMFs on average intake and body weight in a group of 15 LTC residents in Montreal, Quebec. They found a clinically and statistically significant increase in energy intake and weight in the group who received re-shaped food over the study period of 12 weeks, while the group who received traditional scooped pureed food experienced weight loss and a significant decline in intake. This study suggests that re-shaping pureed food items could potentially positively impact intake and weight status in older adults.

Reshaping techniques seem to also be supported to a certain extent by LTC home staff. Ilhamto et al. (2014) interviewed cooks and nutrition managers in various LTC homes across Ontario and identified that 53% would be interested in using food molding and piping techniques to improve the visual appeal of pureed food, but are hesitant to do so due to space limitations, time constraints, and worry about issues of compliance with ministry regulations.

Although these studies showed some benefit of, and some interest in reshaping food products, it seems as though current reshaping techniques may not be producing optimal products resulting in poor appeal to older adult consumers. Stahlman, Gracia, & Hakel (2000) found that healthy older

adults (n=12) preferred non-molded pureed peaches over the molded form. Overall liking and taste were rated significantly higher by 30% and 35% respectively, in the control condition (non-molded). All other attributes, including appearance, texture, and ease of swallow were rated similarly for molded and non-molded fruits. The findings of this study are consistent with those from a more recent and larger study by Lepore, Sims, Gal, & Dahl (2014) where a group of 70 older adults, with a median age of 73, were provided four different pureed food items (chicken, pork, broccoli, green beans), once in a scooped form and another in a molded form. The scooped foods were generally rated more favorably for all sensory attributes: appearance, mouthfeel, and flavor. Additionally, participants demonstrated better recognition of the scooped foods. The authors concluded that issues with gel formation in the molding process could have resulted in lower ratings for mouthfeel, while lack of shape precision could have led to decreased recognition and poor visual appeal of the molded foods.

This modest body of evidence shows that although there is interest and potential benefit in re-shaping pureed food items to their original form, current re-shaping techniques available to LTC homes such as molding and piping seem to be limited at the home and individual level.

2.2 Meal Access: Consistency of Pureed Food

One of the main clinical motives for the provision of pureed food is to promote safe swallowing and to decrease the risk of aspiration pneumonia. In order to achieve this objective, it is necessary to ensure that pureed foods are consistent in terms of rheological properties. The lack of consistency in pureed products is a noted problem of pureed diets as reported by LTC home residents and their family members (Keller & Duizer, 2014b). This issue of lack of consistency in pureed food products was identified on a global scale in a survey by the International Dysphagia Diet Standardization Initiative (IDDSI), which found that only 43% of food service workers tested

the consistency of TMFs and thickened fluids and the most common testing approach was through non-standardized visual inspection (Cichero et al., 2017). These findings are consistent with a qualitative study by Ilhamto et al. (2014) whereby dietary staff reported lack of standardized testing methods for pureed diets and non-conformity with standard pureed recipes. Furthermore, there is an important lack of consistency in terminology used to describe TMFs; one source cited 67 different terminologies to describe textures in 32 nursing homes in Canada (Vucea et al., 2018a). This lack of consistency could be conducive to confusion and may result in the provision of an inappropriate diet texture to LTC home residents, thus increasing the risk of aspiration.

In order to address the issue of lack of consistency in the texture of modified foods, the IDDSI group formulated a framework with descriptors and testing methods for eight levels of food and fluid consistencies (IDDSI, 2016). The traditional "pureed" description is encompassed under level 4 in the IDDSI framework which also includes extremely thick fluids (IDDSI, 2016). Fork drip test and spoon tilt test are the recommended methods of testing level 4 foods; these techniques are further described by IDDSI (2016). However, at this time, the uptake, implementation, and interest in the IDDSI framework remains unclear. For example, a survey by Cichero et al. (2017) indicated that only 49% of Canadian healthcare professionals and food service workers would be interested in implementing IDDSI in their organizations. Effective implementation strategies of the IDDSI framework are still under exploration. Therefore, at this time, it is necessary to explore complementary strategies to ensure that pureed food products are consistent in texture and that common standardized terminology is used to describe these food items. Commercially prepared pureed food, such as 3DPPF, may help meet these requirements and result in decreasing the risks associated with traditional pureed food. It is therefore necessary to explore residents' and care partners' perspective on this novel type of food product and technology.

2.3 Mealtime Experience: Resident Satisfaction and Quality of Life

In general, residents' satisfaction with the food provided in LTC homes in Canada seems to be suboptimal. A cross sectional descriptive analysis of 928 interRAI Self-Report Quality of Life surveys from six Canadian provinces, including Ontario, revealed that only 66% of LTC home residents are satisfied with the food provided in their respective LTC home (Kehyayan, Hirdes, Tyas, & Stolee, 2015).

Although it is important to explore interventions that would improve the quality of food provided in LTC homes in general, particular attention should be given to those geared towards pureed food consumers. A recent analysis of the Making the Most of Mealtime data evaluated theindependent effect of pureed diet on nutritional risk (Vucea et al., 2018). The authors identified that LTC homes residents who received a pureed diet (n=68) were at higher risk of malnutrition even when adjusted for important risk factors for malnutrition such as cognitive impairments, need for eating assistance, dysphagia risk, and poor oral hygiene. These findings suggest that pureed food may be an independent risk factor for malnutrition and therefore residents receiving this type of food could be among the most vulnerable with regard to risk of malnutrition. The association between a pureed diet and malnutrition could be explained by residents' dissatisfaction with pureed food as revealed by Keller & Duizer, 2014b. Additional factors such as refusal to eat, social isolation, and depression as reported by individuals with dysphagia, in the context of requiring a texture modified diet, may also affect nutritional status and quality of life for those individuals (Martino, Beaton, & Diamant, 2009). It is therefore necessary to explore interventions geared towards improving the quality of pureed food and 3DPPF may be one such strategy.

2.4 Policy and Procedures

The Ministry of Health and Long-Term Care (MOHLTC) is the primary regulatory body for policies and procedures for LTC homes in Ontario. Homes that receive funding from the ministry must adhere to strict policies and guidelines which are encompassed in the MOHLTC Act 2007 (MOHLTC, 2007). These guidelines aim to promote residents' health and well-being, safety, and dignity while assuring excellent care provision. The act includes specific sections describing policies and regulations as pertaining to food service operations and nutritional care. For instance, the MOHLTC requires that texture modified foods match regular menu items (MOHLTC, 2007). Although this policy aims at promoting excellence of care, some limitations have been identified by nutrition managers. For example, in a qualitative study by Anciado, Ilhamto, Keller, & Duizer (2012), nutrition managers expressed that one source of hesitation in buying commercially prepared pureed food is the MOHLTC requirement of matching pureed food items to regular food products.

2.5 History of 3D Food Printing

It may be surprising to many that the seemingly futuristic personalized 3D food printer has actually been in existence for a little over a decade. In fact, researchers from Cornell University were inspired by the transition of digital computation in the 1960s from large scale devices, once operated by individuals possessing technical expertise, to small sized user-friendly household items (Malone, Lipson, 2007). Those researchers created a personalized 3D printer, Fab@home, which they introduced to the broader public in 2006. Since then, the 3D food printer gained significant interest and many manufacturers started addressing technical and user-related issues associated with its design, to build an ultimate model (Lupton, 2017; Liu, Zhang, Bhandari, & Wang, 2017). Most models are still in experimental stages and concepts are being developed for

various food-related industries such as the making of confectionary and pasta, personalized nutrition for combat troops, and TMFs for residents in LTC homes (Lupton, 2017; Huang, 2018).

2.6 Types of 3D Food Printers

This proposed research is one component of a larger collaborative project with Dr. Duizer from the University of Guelph, Department of Food Sciences and Dr. Moresoli from the University of Waterloo, Department of Chemical Engineering. Since some of the methods used for data collection will be informed by collaborators' research findings whereby an extrusion-based 3D food printer is used, the following section will focus on this method of 3D food printing. General remarks will be provided about the three other types of 3D food printing: selective sintering printing (SLS), binder jetting printing, and inkjet printing (Liu et al., 2017).

2.6.1 Extrusion-based 3D printing

This technology uses a fused deposition modeling which deposits a hot melted semi-solid material, layer by layer through one of three mechanisms: screw-based extrusion, air-pressure extrusion, or syringe-based extrusion (Liu et al., 2017; Sun, Zhou, Huang, Chambers, 2015). This technique has been applied with various food items such chocolate, dough, mashed potatoes, cheese, meat paste, salmon, and pureed carrots (Liu et al., 2017; Huang, 2018). These foods are all well suited for extrusion-based 3D printing due to their rheological properties, namely their high viscosity and mechanical strength (Liu et al., 2017). An important limitation to this type of 3D food printing is the deformation of structure through conventional post-processing techniques such as heatingand baking of foods. Some studies have shown that recipe manipulation, such as addition ofparticular amino acids or proteins in pre-determined concentrations, could prevent post-processing shape deformation (Liu et al., 2017). Such strategies could be applied if the 3DPPF is to undergo any

post-printing treatments. Another disadvantage of this technology is the long fabrication time of the 3D printed food (Sun et al., 2015; Huang, 2018). The challenge of time for the making of 3DPPF will not be of central relevance for this study as it will be assumed for interviews with participants that the 3DPPF would be commercially prepared and that as this technology improves, the time required for production will be reduced.

2.6.2 Other types of 3D printing

Non extrusion-based 3D food printing technologies such as selective laser sintering, binder jetting, and inkjet printing have limited applicability to food material with high viscosity (Liu et al., 2017). As such, contrary to extrusion-based 3D printing, these technologies are limited to liquids and powders and would therefore not be appropriate for printing complex food items such as pureed food served in LTC homes (Liu et al., 2017; Sun et al., 2015).

2.7 Advancements in 3DPPF: The PERFORMANCE project

The use of 3D food printing is marketed towards specific industries such as customized and gourmet food, NASA and the armed forces, and personalized nutrition for older adults with dysphagia (Liu et al., 2017; Sun et al., 2015; Lupton, 2017). The Personalized Food for the Nutrition of Elderly Consumers (PERFORMANCE) project is a European Union (EU) funded multidisciplinary collaboration between various researchers and industry partners from five European countries (Germany, Denmark, the Netherlands, Italy, and Austria). The main goal of the PERFORMANCE project was to create a concept through which personalized foods are prepared and printed using jet printing which is rapid processing extrusion-based 3D printing (RTSD Group, 2014). The project was carried out between November 2012 and October 2015 and was divided into five distinct Work Packages (WP) which focused on the development of the

ideal combination hydrocolloids and pureed food while considering the shape, texture, and nutritional adequacy of the end products as well as post-printing treatment such as heating in a microwave oven (Community Research and Development Information Service, 2015).

The PERFORMANCE concept has not yet been commercialized in Europe and 3D printed foods are not being distributed to LTC homes in the participating European countries at this time. However, some industry partners are currently exploring opportunities for commercialization. For example, biozoon food innovations™ conducted a taste testing for 3D printed pureed food items in a long-term care home in Germany using the PERFORMANCE concept; 54% of participants rated the texture as good and 43% said they would choose PERFORMANCE if they were experiencing chewing or swallowing difficulties (Community Research and Development Information Service, 2015). The results of the survey reflect a poor level of satisfaction with the 3D printed PERFORMANCE pureed food products and the project leads communicated the need to address some issues reported by participants. Unfortunately, further details regarding participant characteristics, taste testing conditions, and survey methodology have not been published. Therefore, it is not possible to formulate recommendations based on the available information from that survey.

2.8 Consumers' Perspectives of 3D Printed Foods

While the marketing of 3D food printing has been expanding over the last decade, the need of and interest in foods produced using this technology have not been widely explored at the consumer level (Lupton, 2017). Only two scholarly contributions have been published (Brunner, Delley, Denkel, 2017; Lupton & Turner, 2016).

Lupton, & Turner (2016) conducted a qualitative study using an online focus group discussion regarding consumer perception of 3D printed food. The main objectives of the study focused on

food activism and aimed to explore the potential of 3D printed food in reducing waste and enhancing environmental sustainability as well as alleviating world hunger. A total of 30 participants from all seven states in Australia were recruited; the sample was varied in terms of age, occupation, and level of education, and included four older adults, described as retired people in the study. However, it is unknown if these individuals resided in the community or in LTC homes. The study required that participants take part in an online group discussion over a period of four days and share their perception of 3D printed food including positive and negative aspects of these foods. Specific discussion topics geared towards the use of 3D food printing technology to reduce waste and alleviate world hunger were introduced once participants were familiarized with 3D food printing. The qualitative data generated from the study revealed a high level of skepticism regarding 3D food printing technology and this was not overcome by a display of 3D printed foods and meals nor with the provision of information regarding the potential global and environmental benefits of such technology. Since participants had very little baseline interest in environmental practices, it is not surprising that their views remained negative towards the use 3D food printing for environmental causes. On the other hand, when participants were provided options for other applications of 3D food printing, they identified that this technology would be beneficial for older adults who experience difficulties swallowing due to the lack of variety in their diets. This study suggests that consumers' perspective of 3D printed food is likely context-dependent and skepticism may be overcome when perceived benefit outweighs perceived harm.

Brunner, Delley, & Denkel (2017) surveyed 260 people in Germany including 91 community-dwelling older adults whose exposure to and experience with pureed food was not identified by the authors. The objective was to measure consumers' opinion on various aspects pertaining to 3D printed foods. The authors determined that initial knowledge and attitudes were, on average poor

and negative, and although informational statements slightly improved how people perceived 3D printed food, the general attitude towards these novel foods was still negative. Food technology neophobia (Evans, Kermarrec, & Cox, 2010), which is the fear of new food technology, was believed to be the main driver of a negative attitude towards 3D printed foods while the perceived benefits and convenience were the strongest determinants of a positive attitude towards 3D printed foods. The results of this study demonstrate that when evaluating consumers' perception regarding 3D food printing, it is important to provide sufficient knowledge regarding the technology in order to allow for informed decision making and to prevent rejection solely on the basis of food technology neophobia. Consistent with this study, a review by Lyndhurst (2009) reveals that public attitude is generally negative and pessimistic towards novel and emerging food. These findings suggest that an educational component should be incorporated into studies that are targeting attitude towards novel food products in order to ensure that consumers are given an opportunity to make an informed decision regarding these novel foods.

2.9 Study Rationale

Prior research has demonstrated that pureed food does not live up to expectations with respect to visual appeal; 3D printing technology is available which may provide a solution. From an implementation science perspective, it is necessary to establish an understanding of the potential uptake of an intervention, including its perceived limitations, opportunities, and barriers prior to implementation within a particular context (Straus, Tetroe, & Graham, 2013). From a consumer and professional behavior perspective, this knowledge is required to ensure that there is factual and scientific rationale to support novel products, such as 3D printed food (Popa & Popa, 2012). Finally, from a population health perspective, particular attention should be given to population needs' assessment for emerging scientific discoveries, advancements, and interventions

such as novel food technologies, where the public attitude is generally negative and pessimistic (Lyndhurst, 2009).

Research in the area of 3D food printing is very scarce in general and nonexistent in the healthcare field, while industrial developments are advancing at a much faster rate. In order to promote safe, ethical, evidence-based, and effective uptake of this novel type of food, it is necessary for scholars to conduct research that explores the potential of these novel foods while considering contextual multi-level factors and soliciting various social actors.

Chapter 3: Objectives, Research Questions and General Methodology

3.1 Objectives and Research Questions

Part 1: Registered dietitians' perspectives on the potential for 3DPPF in LTC (Chapter 4)

Objective: To explore the perspectives of registered dietitians on the potential for a novel food product, namely 3D printed pureed food (3DPPF), as an alternative to other types of pureed food offered in their homes.

P1-1 What are the potential benefits, advantages, limitations, and challenges related to 3DPPF as perceived by registered dietitians?

P1-2 What are the sensory, nutritional, and quality requirements for 3DPPF as identified by registered dietitians?

P1-3 What are some clinical and ethical implications associated with 3DPPF?

P1-4 What are some home-level considerations associated with 3DPPF?

Part 2: Residents' and family members' perspectives on the potential for 3DPPF in LTC (Chapter 5)

Objective: To explore residents' and family members' perspectives on 3DPPF as an alternative to other types of pureed food offered in their homes.

P2-1 What are the potential benefits, advantages, limitations, and challenges related to 3DPPF as perceived by residents and family members?

P2-2 What are the sensory, nutritional, and quality requirements for 3DPPF as perceived by residents and their family members?

Part 3: Dietary team members' perspectives on the potential for 3DPPF in LTC (Chapter 6)

Objective: To explore dietary team members' perspectives on the feasibility and potential usefulness of 3DPPF as an alternative to other types of pureed food offered in their homes.

P3-1 What are the potential benefits, advantages, limitations, and challenges related to 3DPPF as perceived by dietary team members?

P3-2 What are the sensory, nutritional, and quality requirements for 3DPPF as perceived by dietary team members?

P3-3 What are some procedural, home-level, and governmental considerations for the potential use of 3DPPF in LTC homes?

3.2 General Methodology

As demonstrated in the background section of this thesis, there is little research about 3DPPF in general and in LTC homes in particular. It is therefore most effective, at this time, to conduct a study that allows for exploration rather than generalization of findings. In using a qualitative study design, this work would help reduce the ambiguities and uncertainties regarding the potential of 3DPPF in LTC homes, while generating questions for further research and development in this area (Soafer, 1999).

An interpretive description strategy guided the formulation of the study purpose and design. This qualitative research strategy aims at creating knowledge that is relevant to and applicable within a particular community or area of practice (Thorne, Kirkham, & MacDonald, 1997). The exploratory nature of this work and the requirement to gain an in-depth understanding of the subjective

perspective of various participant groups within the Ontario LTC context justifies the use of this qualitative research design. In deviating from strictly using a traditional qualitative methodology such as ethnography, phenomenology, or grounded theory and instead incorporating pertinent aspects from all three traditions, interpretive description allows for the creation ofknowledge that is translatable to applied health (Thorne, 2008). In using interpretive description, researchers appraise knowledge from all sources and review a mix of scholarly and professional knowledge while considering disciplinary biases and commitments (Hunt, 2009). The ultimate goal of using this design and analysis strategy is to create useful knowledge that has relevant basis within a community of practice consequently serving as a clinical reference. Thorne (2008) describes interpretive description as a "conceptual maneuver whereby a solid and substantive logic derived from the disciplinary orientation justifies the application of specific techniques and procedures outside of their conventional context" (p. 35). This thesis was informed by relevant scholarly, professional, organizational, and governmental resources and acknowledged organizational limitations and professional philosophy, consistent with the interpretive description methodology.

An interpretive approach guided the formation of research questions, objectives, methods, and data acquisition. As such, the study was designed based on previous knowledge presented in the background. Results are presented based on the subjective perspectives of participants and the interpretation of accounts by the student researcher. This interplay between knowledge, participants' experience, and researcher's interpretation forms the basis of an interpretive theoretical orientation. Participants' accounts were analyzed using inductive thematic analysis which allowed for grounding the themes in the data rather than fitting them into a pre-existing theoretical framework (Braun & Clarke, 2006).

This study was conducted based on the principles of credibility, transferability, dependability, and conformability which aim to ensure rigor and trustworthiness of qualitative research studies (Thorne, 2008; Thomas & Magilyy, 2011). Credibility was achieved through reflexive journaling, peer debriefing with the PI, and data triangulation (Thomas & Magilyy; 2011; Anney, 2014). In this study, two types of triangulation were used: data triangulation and investigator triangulation (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014). Data triangulation was achieved through the exploration of different perspectives to increase the validity of the study; as such, three groups of stakeholders were included to gain a comprehensive understanding on the potential for 3DPPF in LTC. Triangulation was also used to validate the analysis process by involving two investigators, the primary author and the senior researcher, in data analysis and theme development. In using interpretive description, the study ensures transferability of findings based on an understanding of relevance to population needs and to clinical practice. Additionally, context was thoroughly examined during the data collection and analysis process in order to promote transferability of findings to similar settings. Dependability was achieved through the creation of an audit trail to describe all the steps undertaken to formulate the study purpose, design, data collection, and analysis; including reflections, analytical process, and thematic memos.

Finally, in using different strategies to promote credibility, transferability, and dependability, conformability of findings could be maximized. It is important to note that conformability is essential in applied health research as the objective is to create knowledge that is relevant to practice and while generalization is not the focus of this type of research method, findings should still be credible and applicable (Thomas & Magilyy, 2011).

3.3 Setting for sample recruitment

Five homes located in Central and Western Ontario were included in this study. This was a convenience and purposive sample as diversity in how pureed food was currently produced/provided in these homes was desired. The senior researcher had contact with these homes in prior research and they expressed interest when introduced to the project. Four out of the five homes were for-profit and belonged to larger corporations of a chain. One home was a charitable, not-for-profit, organization. The sizes of the homes were medium to large with the smallest home accommodating 96 residents and the largest home holding capacity for 192 residents. All homes confirmed the offering of pureed food to their residents when required. Participants were recruited with the collaboration of gatekeepers to these homes who were provided scripts and e-mail templates to assist with the process of recruiting residents, family members, and dietary team members. Additionally, informational flyers were posted in high traffic areas to draw attention to the project and invite stakeholders for participation. RDs were recruited from these five LTC homes and to increase the sample, through the Dietitians of Canada (DC) Gerontology Network, with the assistance of the network's chair.

3.4 Ethical considerations

Ethics approval was obtained from the University of Waterloo Research Ethics Board (ORE#31978). Participants provided informed written consent or e-mail confirmation acknowledging understanding study details and consenting to participate in the study. Verbal reminders regarding confidentiality and ability to withdraw at any time were provided at the beginning of each DG/interview. Participants were aware that some of the quotations would be used in the dissemination of this work and that these would be de-identified.

Chapter 4: Part 1. Manuscript 1: Registered dietitians' Perspectives on the Potential for 3D Printed Pureed Food in Long-Term Care Homes

Unsubmitted Manuscript

Background. Registered Dietitians (RDs) play an important role in providing pureed food to LTC homes' residents through their involvement in nutrition and swallowing assessment, care planning, diet prescriptions, and nutrition and hydration quality initiatives. The purpose of this study was to explore RDs perspectives on 3D Printed Pureed Food (3DPPF) as an alternative to current types of pureed foods offered in LTC.

Methods. This was a qualitative study with an interpretive description method. Purposive sampling was used to recruit RDs from five participating homes and through the Dietitians of Canada Gerontology Network. A total of 10 RDs were recruited to participate in small discussion groups (DGs). The first author and senior researcher conducted 4 DGs with RDs through teleconference to accommodate for geographical proximity. Discussions followed a semi structured guide to explore RDs perspectives on the opportunities, challenges, limitations, barriers, and potential for 3DPPF in LTC. Verbatim transcription was done by the first author for all DGs. Transcripts were coded line-by-line and meaningful themes were identified by the first author and confirmed by the senior author.

Results. Three over-arching themes emerged from the qualitative data. RDs spoke about weighing the risks against the benefits of a pureed diet with residents and families. They shared that there would be an opportunity for 3DPPF to help market pureed food more positively to residents,

families, and team members. Finally, they discussed concerns around applicability, workability, and product quality of 3DPPF.

Discussion. RDs identified issues with acceptability and appeal of traditional pureed food and described that 3DPPF could help overcome these issues. They shared that in order for the product to be an acceptable alternative in LTC, it should deliver on quality in terms of nutritional content, sensory attributes, texture and consistency, ingredients and additives, variety, and food safety. They also described that a contextual evaluation and a piloting phase would be required to ensure that 3DPPF meets LTC standards, is acceptable by residents and staff, and is workable within the LTC context.

Conclusion. RDs believe that 3DPPF could increase the acceptability of pureed diet and improve residents' dining experience. However, products should deliver on quality and fit within the LTC procedural and policy requirements while accounting for resource availability and training needs.

4.1 Introduction

Ageing often results in impairments in individuals' physical, functional, and cognitive capacities; chewing and/or swallowing are examples of functions that are sometimes compromised with ageing, resulting in a condition called dysphagia. Institutionalized older adults are at higher risk of dysphagia with 40-60% of long-term care and nursing homes residents suffering from this condition (Aslam, Vaezi, 2013; Wirth et al, 2016).

Dysphagia assessment and treatment are performed by Speech-Language Pathologists (SLPs) and dietitians in LTC homes. One of the main approaches recommended by these regulated health care professionals to manage dysphagia is the consumption of modified texture food and/or thickened fluids (College of Dietitians of Ontario, 2018). Unfortunately, this strategy is not always successful as these foods and fluids can be unappealing to residents (Keller & Duizer, 2014b). The Dysphagia Policy from the College of Dietitians of Ontario (2018) outlines the purpose of dysphagia assessment as the recognition of risks of choking and aspiration and identification of the most appropriate nutrition care plan, including food texture and fluid consistency based on risk reduction, individual choice, and informed consent (College of Dietitians of Ontario, 2018). The principle of informed consent in healthcare is mandated by law to all healthcare professionalsand is emphasized in the Ontario *Health Care Consent Act*; theoretically, the balance between safety and choice seems easily applicable. However, in the context of pureed diets, this balance may prove challenging due the frequent refusal of pureed diet which is often driven by the poor sensory properties of the food and the difficulty to distinguish pureed food items (Keeffe, 2018; Keller & Duizer, 2014b; Blaise, 2009, Lepore et al., 2014).

In order to help overcome the issue of acceptability of pureed food and to promote resident safety, a few studies have explored creative solutions aimed at reshaping food products to help improve the quality and appeal of pureed food for these consumers; some showed promising impact of shaped pureed food on residents' intake and acceptability of pureed diets (Cassens, Johnson, & Keelan, 1996; Germain, Dufresen, & Grey-Donald, 2006). However, others (Stahlman, Garcia,& Hakel, 2000) identified issues with taste, texture, and mouth feel of reshaped products due to the excessive use of thickener for shape holding.

This project explores the potential for a novel product, namely 3D printed pureed food (3DPPF), in improving the appeal of pureed food, overcoming some of the issues associated with its acceptability, and enabling RDs to advocate for residents' choice while promoting safety. At this time, it is unknown whether 3DPPF would resolve some of the dilemmas associated with dysphagia management; for example, this type of pureed food may result in increased acceptance of the recommended texture. Alternatively, availability of 3DPPF may add another layer of ethical dilemma for RDs, since the technology is still in the experimental stage and its novelty might result in resistance towards uptake despite the minimal evidence regarding its benefits and safety (Lupton, 2017; Huang, 2018). The aim of this study is to investigate LTC RDs' perspectives on 3DPPF to gain a deeper understanding on the perceived usefulness, benefits, limitations, and considerations required with this novel type of pureed food in relation to its clinical and ethical implications within the LTC context. Such knowledge is relevant before further investment in the technology and to provide guidance on important considerations that will lead to uptake.

4.2 Methods

4.2.1 Overview

This was a qualitative descriptive study with an interpretive, inductive thematic analysis that examines perspectives of residents and family members, dietary team members and dietitians. Five Ontario LTC homes that were part of the researchers' network were purposely sampled and invited to participate in the study. The LTC homes included in this study represented a variety of business-models (for-profit and not-for-profit). All homes confirmed use of pureed food residents; details about the types of pureed food offered at the participating homes is found elsewhere (This information will be included in the team members' paper which will be submitted to various journals and it should therefore be cited here). Only the analysis based on dietitians' perspectives is presented here.

4.2.2 Participants

Dietitians were recruited using purposive sampling strategy from the five participating LTC and to increase numbers, through the Dietitians of Canada (DC) Gerontology Network. Eligibility criteria included current or recent past work experience as an RD in a LTC home or as an RD in the LTC sector in Ontario within the past 10 years. This timeframe was justified based on the release of the Ministry of Health and Long-Term Care Act in 2007, which dictates RDs practice within Ontario's LTC homes. A total of 10 RDs (n=10) were recruited to participate in this study and a total of 4 small group interviews/discussions (DG) were conducted to accommodate for RDs' availabilities.

A demographic questionnaire was completed by RDs and returned to the research team prior to the DGs, 8 of 10 were returned. All participants were female and the majority had considerable work experience in LTC; 70% of participants reported having more than 5 years of experience as an RD in LTC. Participants were very involved in dysphagia management and provision of recommendations for changes in diet texture/fluid consistency however their knowledge about 3DPPF was very limited. Table 4.0 provides information about the participating RDs.

Table 4.0 Participant Information (n=10)

Demographics Information		**n (%)**
Gender	Female	10 (100%)
Age (Range)*	22-35 36-35 55+	1 (10%) 4 (40%) 3 (30%)
Years of Experience in LTC*	1-3 years 3-5 years 5+ years	1 (10%) 0 (0%) 7 (70%)
Work Status in LTC*	Full time Part Time	3 (30%) 5 (50%)
Swallowing Assessment Performed by*	RD Speech-Language Pathologist (SLP) Both but predominantly RD Both but predominantly SLP	2 (20%) 0 (0%) 5 (50%) 1 (10%)
Recommendations for Changes in Diet Texture are Made by*	RD Speech-Language Pathologist (SLP) Both but predominantly RD Both but predominantly SLP	2 (20%) 0 (0%) 6 (60%) 0 (0%)
Level of Knowledge about 3D Printed Pureed Food*	Minimal Moderate Advanced	7 (70%) 1 (10%) 0 (0%)
***Missing data**		2 (20%)

4.2.3 Discussion Group Data Collection

DGs were between 45 and 60 minutes in length and were conducted through teleconference/webinar technology to accommodate geographical limits. The first DG was conducted by the senior author with the first author completing the remaining discussions; both were present for all but the final discussion group. The structure of each DG included three distinct parts; the first was a discussion around the RDs' experience with ordering and recommending a pureed diet to residents, including acceptability of and feedback about the pureed food. The second part was an introduction to 3DPPF through a researcher-developed video presentation of pureed carrot medallions. Participants were encouraged to ask questions about the technology, as a means of identifying potential areas of concern. The third part was a discussion with a focus on exploring RDs' perspectives on the potential for 3DPPF within the LTC context. Discussions were based on a semi-structured interview guide (Table 4.1) and data collection was an iterative process whereby questioning and discussions were updated according to emerging ideas, findings, and interactions with early DG. DGs were audio-recorded and verbatim transcription completed by SA.

Table 4.1 Interview guide for RDs DGs

Structure of the Discussion Groups	
Part 1 *Understanding RDs experience with recommending/ ordering pureed food*	What are some reasons why you would order pureed food for residents? What are some negative health implications you see with a pureed diet? Can you remember a time you recommended a pureed diet and resident (or their family member) refused your recommendations?
Part 2 *Presenting and describing 3D printed pureed food to RDs*	*Introduction to 3DPPF though video presentation and narration of production process (food used in video: pureed carrots shaped into medallions with the 3D printer). The video provided a presentation and description of: 1) the food pureeing process and environment, 2) the 3D printer and the printing process, 3) the steps of storing in a freezer and the retherming in a conventional oven, and 4) finally the presentation of 3D printed pureed food on the plate.*
Part 3 *Exploring RDs perspectives on 3D printed pureed food and addressing their questions and concerns.*	What are your thoughts on this new way of making and presenting pureed food? In what ways could this type of food help with overcoming some of the issues associated with pureed food? What would be the requirements for this type of food to overcome some of the issues associated with a pureed diet? What would be some challenges you foresee with this type of food in LTC? What other information would you need in order to decide whether or not you would recommend this type of pureed food for residents?

4.2.4 Data Analysis

All DGs were analyzed by one researcher (SA) with the senior author (HK) providing support and guidance at every step of the analytical process. Coding guidance was informed by grounded theory which calls for the application of several levels of coding to develop a substantive theory (Thorne, 2008). In this study, only open and axial coding were used to develop themes; open coding is applied first and it consists of fracturing of the data to examine similarities and differences. This is followed by the identification of axial codes to connect and categorize the textual fragments (Thorne, 2008). An inductive analysis approach was used with the constant

comparison technique applied to help uncover commonalities across RDs accounts (Thorne, 2008). All coding was done manually using Word Processor 2010.

Once coding was completed and codes were reviewed and confirmed by HK, meaningful and useful themes and sub-themes were identified by grouping codes that represented similar ideas. Thematic memos were developed based on the proposed themes, sub-themes, and potential quotes supporting each theme. These were then reviewed by HK who provided feedback and recommendations for revision. A final copyof the thematic memos was then drafted which became the results for this manuscript

4.2.5 Ethics and consent to participate

Ethics approval was obtained from the University of Waterloo Research Ethics Board (ORE#31978). RDs provided informed written consent or e-mail confirmation acknowledging understanding study details and consenting to participate in the study. Verbal reminders regarding confidentiality and ability to withdraw at any time were provided at the beginning of each DG. Participants were aware that some of the quotations would be used in the dissemination of this work and that these would be de-identified.

4.3 Results

RDs' accounts from all DGs revealed that participants' recognized the need to enhance the quality of the pureed food in order to improve appeal, acceptability, and nutritional value. Three major themes emerged from the DGs. RDs described nutritional concerns associated with pureed diets and talked about the approach they use in weighing the risks and benefits associated with these diets with residents and families. They also highlighted many issues with acceptability ofpureed

foods and offered a perspective on how 3D printing could be used to market pureed food more positively. Finally, RDs shared contextual and quality considerations and identified workability issues to be taken into account, should this novel type of pureed food be considered for implementation in LTC. Further elaboration of the themes is provided in Table 4.2.

Table 4.2 Summary of themes

Weighing the Risks Against the Benefits of Pureed Food with Residents and Families	
Justifying a pureed diet prescription	*"I do it just for swallowing problems. When they have a swallowing assessment, it could be someone with severe dementia who can no longer remember to chew and then they're at risk for choking. Or it could be somebody with a stroke, sometimes Parkinson's, ABI."RD1, DG1* *"Difficulty chewing, pocketing food, trouble manipulating food in the mouth, ill-fitting dentures. And some residents also request it because it's easier to eat and requires less energy expenditure."RD2, DG3* *"We would also have on occasion residents with denture issues who would require pureed food but I try to avoid putting someone on strictly a pureed just because their dentures are missing because often they will tolerate safely a soft or minced texture"RD3, DG1*
Negotiating risks and benefits with residents and family	*"So for me there is a few reasons; one if they have trouble swallowing their food. Two if they have trouble chewing or their dentures don't fit properly and they don't have the financial resources to invest in new dentures. It is usually a conversation I would have with the resident first and if they can't speak for themselves, I would speak with the Power of Attorney/Substitute Decision Maker. First and foremost, it's about safety for the resident and then I usually look at quality of life as well; so if they aren't able to chew for whatever reason and they're okay with pureed I would order it for them, some would actually even request it for themselves because they find it easier to eat. So yea, these are some of the reasons I would order puree in my day to day practice" RD1, DG3* *"I have for sure, and in this case the resident herself was cognitively aware… we were able to have a team meeting with her family and we heard her refusal for the pureed diet"RD1, DG2*
Decreasing the risk of malnutrition by improving sensory appeal and nutrient density	*"Uhh, with the pureed diet. I can see well, not all residents accept the pureed diet so they don't consume like 100%, they don't really have a good food intake. So as a result, I could see them losing weight or losing their muscle mass. Being deficient in micronutrients". RD1, DG4* *"I also think that maybe during the processing of the foods into a pureed texture then it may cause some loss in minerals and vitamins as well (in reference to traditional pureed)"RD1, DG4* *"They might enjoy their mealtime more and engage instead of looking at the scooped puree three times a day and thinking "I have to eat this"" RD1, DG3*
Using 3D printing to market pureed food more positively to residents, families, and team members	
Changing the attitude towards a pureed diet prescription	*"No I agree very similar experiences <laughter>. There is a lot of stigma around pureed texture food. It doesn't usually look visually appealing, so whether its staff assisting residents, or residents themselves or family members. That can be a barrier." RD2, DG2* *"Some negative aspects of the puree diet is Power of Attorney/ Substitute Decision Maker being upset for having their loved ones receiving "mush" food even if safety is a priority." RD2, DG3* *"One of the strategies if a resident is requiring help is to have a staff at the table and engaging with the residents with a positive attitude about the food that's in front of them."RD1, DG2*

Selling pureed food to residents and families	*"But I haven't had anyone other than family, because most residents on pureed kinda don't know who they are anymore, their dementia is pretty advanced and they can't really comment on it. Family are usually pleased with the look and staff too, they like how it looks like. (in ref to molded pureed)" RD1, DG3* *"They do like to have that nice garnishing, they don't want to see someone else getting a nice slice of cake and them having just bowl of mush in front of them, so we try to slur it and garnish it such that it maintains the appeal." RD1, DG2* *"So, now we do show pureed show plates and the pureed diet is more acceptable that way."RD1, DG1*
Being on the cutting edge	*"Very excited to hear minimal use of thickener which would result in a more nutrient dense product, so that excites me."RD1, DG2* *"And then as I mentioned, you can put vitamins and minerals to the 3D printed products to enhance the nutritional value of the food that's put into the syringe, they would be meeting their nutritional needs that way, in a way of vitamin and mineral powder or things like that that you can add. "RD1, DG4*
Finding Solutions that are Workable	
Working through the logistics	*"Mine would be just that the ministry only allows a certain amount of money for staffing so would there be enough time? I mean many of them don't even take breaks because they just want to be in control of what's going on, kinda thing."RD1, DG3* *"The primary issue in this point in time would be the retherming. And, as many of the serveries do bulk service, how could you then do the service for 30+ plates without retherming them in the dining room?" RD1, DG1* *"My initial thoughts would be: in a smaller home, do we have the freezer capacity"RD1, DG2* *"Yea piping the food into the plate, timely it was taking too much time as the number of residents requiring pureed grew, it just wasn't cost effective. As RD1 mentioned, it's faster to just take a scoop out of a cart than having to pipe it out. But just visually, the visual appeal of the product. As well as the consistency of the product." RD1, DG2* *"Also, I'm thinking how it would be packaged such that we knew there was let's say 10 serving of the carrots and we knew we would have to take out half of that to be able to serve half of that."RD1, DG2* *RD2: I think too, what we saw was 6 medallions on the plate. So we'd have to make sure there's enough room on the plate for your protein and your potato, and that would be obviously a challenge if the medallions took the whole plate, basically. RD2, DG2* *"I am thinking it might be more convenient for them to use because they wouldn't have to do the initial preparation of the food. They would just be cooking it, essentially."RD1, DG4* *"I can see this also decreasing staff time for food preparation and testing because now that the product is pre-made, they would not have to test its consistency as point of service."RD3, DG1*
Key considerations for	*"So during retherm, when moisture or heat is added to it, then it doesn't dissipate? The medallions would hold their shape? They wouldn't dissipate?" RD2, FG2*

creating a quality product	*HK: Yea some of the molded foods sometimes have a spongy feel to them, so it really depends on how much thickener is added.* *RD1, DG3: Yea. I don't think anyone eats our bread pucks as much as we order them and offer them I don't think anyone eats them. That's a puree product that needs improvement.* *"A lot of vegetables and salads just don't make it or aren't starchy enough to be able to hold their shape so they just end up turning into mush. Or a lot of cornstarch has to be added and then it doesn't taste as good. So if you want a salad, you're about to eat a pureed salad, it's not a nice experience you know what I'm saying."RD1, DG3* *Oh so I was thinking something like a stir fry, how would you puree it and 3D print it when it's multiple ingredients? I guess it loses it shape right?" RD1, DG4 "*
Piloting with staff, residents, and families	*"So, so some foods… You actually can boost the nutritional content of food when pureeing it, so it's just working together with staff to make sure they're getting the nutritional content they're ordered to have. Does this make sense?"RD1, DG3* *"There are only 5 or 6 residents on puree and only one who could tell you about the shaped puree. I did discuss with her and even with her personality, she was kinda indifferent. She was like "Oh well, I've been on this for years" so it doesn't really impact her which I find interesting because she had been eating pureed for years but she was just a quiet lady who accepted where she was in life kinda thing." RD1, DG3*

4.4.1. Weighing the risks against the benefits of pureed food with residents and families

RDs described their clinical justifications for recommending a pureed diet including swallowing issues, dental/denture issues, and ease of eating pureed food. They spoke about how they draft their recommendation based on a careful weighing and individualized evaluation of potential risks and benefits of pureed diets. Their goal was to promote informed decision making by helping residents and families weigh the risks associated with a pureed diet against the benefits of the diet.

Most of the discussion around risks and benefits focused on quality of life considerations and nutritional health. Quality of life was described as being affected either positively or negatively by a pureed diet prescription, depending on the resident. As such, residents' quality of life could be improved with a pureed diet if the diet provided more energy to participate in activities. Alternatively, residents could be negatively impacted by the diet if they disliked the sensory appeal of the food and, as a result, refused to eat.

> *For some, it helps them get more energy; so if they aren't able to get the energy they need in the day to help them feel well or be awake for certain activities that the home offers; you know…having that chat with them and say you know, as much as you might not want to have that pureed food, a couple of meals a day give you the energy you need to participate or the energy you need to walk around or do something.* (RD1, DG3)

> *A lot of it is about the look and the texture of the food and I guess as you get older, your taste buds diminish as well, so if it doesn't taste good then they're probably not going to eat it as well. So that's typically why they would try to push for a regular diet or something like that.* (RD1, DG4)

Once the benefits, risks, and consequences of a pureed diet were identified by RDs, the recommendations were presented to residents and families and a process of negotiation of risks and benefits was undertaken to help with decision making. Although RDs based their suggestions on clinical considerations and risk reduction such as safety and nutritional health, they acknowledged that, ultimately, the residents and/or their Power of Attorney (POA)/Substitute Decision Maker (SDM) had the right to refuse and to choose to live with the health risks associated with not consuming a pureed diet.

> *I have a resident who had come in from hospital. And I believe she had a seizure episode and I did recommend the puree diet but the family did not want her on that and they continued to give her a regular diet which she was on before. But it was a matter of monitoring her and seeing how she does {with the regular diet} and so far she's been doing okay. There are times where she does cough on the food but, like I guess in LTC, you kinda have to follow the POA's wishes, so you kinda have to respect that so it's not really up to me to decide what they're gonna be on.* (RD1, DG4)

In some instances, residents and/or families accepted the RDs' recommendations, but the diet would be unappealing for the residents resulting in a decreased intake, malnutrition, weight loss, and nutrient deficiencies. In other situations, a pureed diet prescription was thought to potentially increase the risk of malnutrition irrespective of intake, as food products were perceived to have lower nutritional value in comparison to the regular diet: *"It tends to be, not always, but often, lower in calories and lower in protein. So you have to be careful, when you switch them to a pureed diet to ensure that their protein and calorie intake is adequate. "(*RD1, DG1). These factors justified RDs' interest in improving the nutritional value of pureed food through fortification… *"with milk protein, whey protein, and Carnation Instant Breakfast"* (RD2, DG3). Although

fortification may be effective in overcoming nutritional quality concerns, sensory attributes may continue to impact acceptability and intake. One RD described how 3DPPF could decrease nutritional risks associated with a pureed diet prescription if it overcame these sensory problems:

> *I think it's a great technology to make pureed food because I think the texture and the look are what people look at when they're eating so I think this technology would help increase their food intake….. And I also think that you can add vitamins and minerals into the syringe to just increase the nutritional value as well.* (RD1, DG4)

4.4.2 Using 3D printing to market pureed food more positively to residents, families, and team members

The issue of acceptability of a pureed diet was thought to be affected by individual preference and culture; social dynamics were believed to play an important role on how the diet was perceived by residents, families, and team members. There was agreement that creative and innovative solutions were required to market pureed food more positively to consumers. In being on the cutting edge, 3DPPF may offer a more desirable alternative to other types of pureed foods and could therefore improve the appeal of and attitude towards a pureed diet, consequently increasing acceptability and enjoyment of pureed food.

Although RDs described that they primarily focus on resident needs and individual requirements when recommending nutritional interventions, they also noted that they evaluate the effect of environment and culture on food choices and preferences. Within the communal LTC dining areas, they described some practices that weren't supportive of pureed diets, often resulting in a negative attitude towards and poor acceptability of the diet. More specifically, the issue of regular show plates and tablemates' diet incompatibility were significant areas of concern for RDs:

> *In the beginning of meal service they have show- plates. And then they make them choose their meal and what they get, it's different from what the show plate looks like. And so as a result umm some negativity [e.g., expressions, comments] towards pureed food as well.* (RD1, DG4)

> *I think too some of them might even be self-conscious if they are at a table and everyone is getting regular texture food whereas if they were at a table where everyone received pureed they wouldn't even necessarily know it's a puree product. It also might even change their view on receiving that texture.* (RD1, DG2)

In addition to dining room practices, team members' attitudes were an important factor that was thought to directly influence residents' acceptability of the diet; one RD shared some inappropriate comments used by team members to describe the pureed food and elaborated on how this negatively impacted residents in terms of diet acceptability, intake, and enjoyment of the meal.

> *So I see it most often with the staff commenting on what is being served to the resident. Negative comments. You know, like "it looks like a dog's breakfast", "it's all [one] color", "why would anybody want to eat that". Or in the case of a pureed salad, it's like "why would you want to eat a pureed salad?" So very negative comments in front of the resident makes it very difficult to encourage the resident to want to eat that, if they're hearing that when it's placed in front of them.* (RD1, DG2)

These procedural and practice influencers on the acceptability and enjoyment of pureed food are mainly driven by its poor visual appeal: *"The visual look of the pureed food isn't appealing and often looks the same shape on the plate"* (RD2, DG3). Negativity towards the pureed diet may also be a result of its inconsistent texture, which was sometimes affected by preparation methods

…in the case of the home I work in, there is a lack of consistency at times because we do have different cooks who prepare the pureed…if I ask them to puree a muffin for example, you can get inconsistencies in the texture of the puree. (RD1, DG2).

In hopes of changing the negative attitude towards pureed diets, RDs tried to normalize pureed food and improve its acceptability. Table 4.4 provides specific strategies shared by RDs in the DGs to increase the acceptability and appeal of pureed food. Most of these approaches focus on balancing safety and food quality by offering foods that are familiar, recognizable, and visually appealing to pureed food consumers.

Table 4.3 Strategies used to increase the acceptability and appeal of pureed food

Strategy	**Rationale**
Presenting pureed show plates	Ensuring that show plates are representative of the meal that is offered to resident, avoiding any disappointment with the food once received.
Offering more regular-looking pureed food (ex: yogurt, pudding, and mashed potatoes)	Offering foods that are familiar, recognizable, and visually appealing to residents while promoting safety.
Offering more of the pureed foods that are preferred by residents (ex: more hot items than cold plates/cold sandwiches)	Improving intake and acceptability of the diet. Promoting enjoyment of the meal.
Using garnishing and spices	Improving the visual appeal of the food, especially for items that are preferred by residents (ex: desserts, mashed potatoes).
Providing an individualized, liberalized pureed diet by offering some non-pureed foods that the resident is able to tolerate (ex: cornflakes and milk, minced sandwiches)	Balancing between safety and choice; improving intake by offering a combination of pureed and non-pureed items. Promoting enjoyment of the meal.
Offering molded and shaped pureed products	Offering foods that are familiar, recognizable, and visually appealing to residents. Promoting safety and enjoyment.

When introduced to 3D printing technology, RDs thought that it may be an effective strategy to 'sell' pureed food to residents and families: *"The visual appeal that would come in if the pork chop looks like pork chop and the broccoli looked like broccoli and so on and so forth, would be great."* (RD1, DG2). One RD shared some feedback that she received on molded food and explained that although most residents aren't able to voice their opinion due to significant cognitive impairments, family and staff were very pleased with these molded products due to their improved visual appeal. Similarly, it was described that 3DPPF, *"would be very well-received on the resident and family end. It would be a great marketing opportunity and it would be amazing. "(*RD1, DG1)

RDs' excitement about this cutting-edge technology was also driven by the potential for consistent pureed food products. They thought that 3D printing could help support pureed food by ensuring minimal use of thickener and offering food that complies with the International Dysphagia Diet Standardization Initiative (IDDSI) standards (IDDSI, 2016). One RD spoke about the uniqueness of 3D printing in assisting with IDDSI implementation:

> *As you try to implement the IDDSI standards, there aren't a lot of products on the market, yet, that meet some of the criteria. That applies to purees, minced, and moist food. So there will be a lot of demand for products that meet this criterion. (*RD2, DG1).

The need for improvement in commercial pureed was also a result of the limited variety of foods offered in pre-shaped format; this was a major limitation discussed by RDs who had experience with molded and pre-shaped pureed food. "*Our home does have the shaped puree, the [Manufactuer Name] product but they only offer so many options so sometimes residents receiving pureed don't have the shaped look to it."* (RD1, DG3). Additionally, RDs thought that commercially prepared 3DPPF would be particularly attractive if it offered nutrient dense foods,

potentially through methods of fortification: *"It would also be more useful to use this product if it was actually fortified so for example pureed carrots with added protein would increase its attractiveness. This would solve the mystery of whether we are lowering the nutritional contentof the food by making it through this technology. "*(RD3, DG1). In this regard, innovation and novelty were perceived positively however, in another instance, concerns around safety of the technology were raised *"I guess uhh like maybe umm if there's any radiation or anything like that that would affect the food when it's being made and you would wanna see if there are any long term effects of the food."* (RD1, DG4).

Finally, it was recognized that 3D printing may be helpful with the changes in population trends and people's interest in food composition however it was thought that it may not be an effective solution for all residents. In order to ensure effectiveness in improving the acceptability and appeal of pureed food, it was noted that 3DPPF should be developed though continued testing and benchmarking as RDs seemed to have a keen interest in reproducibility and were wondering *"Has anyone else in the world done this?"* (RD1, DG3).

4.4.3 Finding solutions that are workable

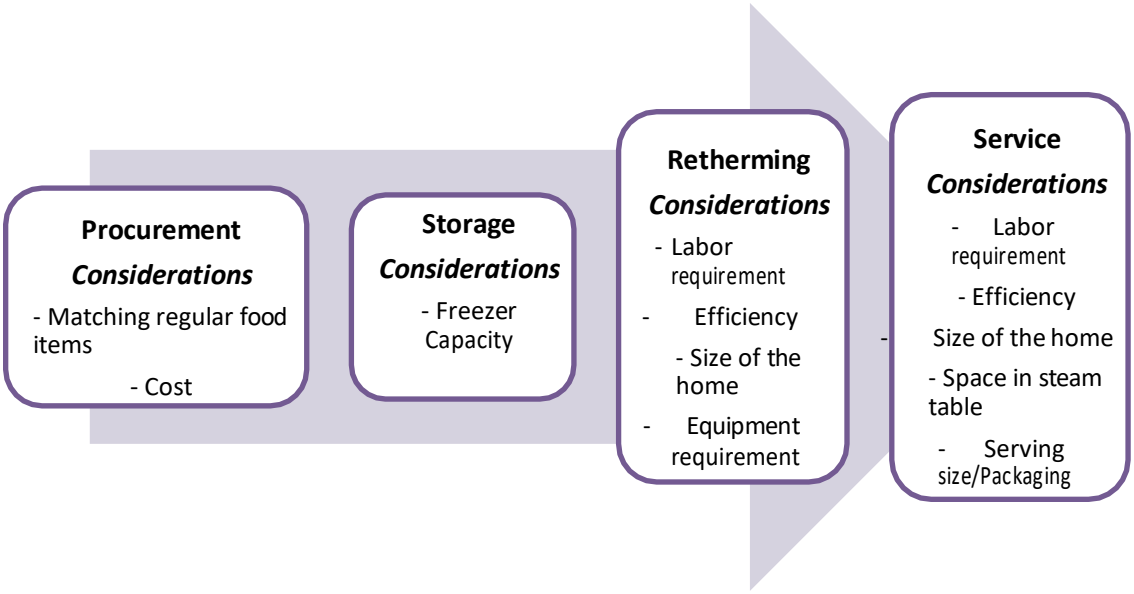
The idea of 3D printing for pureed food was described to RDs via video presentation in order to ensure understanding of all the steps involved in the process; it was of primary importance to explore RDs' perspective on how this technology would fit into the LTC context. RDs held a strong belief in finding solutions that were workable to overcome the issues associated with pureed food. One RD summarized the general sentiment towards this technology with regard to workability: *"Yea and it's exciting, given that the population is ageing, this is huge, and it would be great to see something different is done that is workable."* (RD2, DG2). By working through

logistics, offering a good quality product, and piloting 3D printed pureed food with consumers and staff, the uptake and desirability of 3DPPF would be maximized in LTC homes: "*I think it would be a great way to sell pureed food to family as long as the nutritional value is adequate and that it does not cause any problems for the kitchen and the labour"* (RD2, DG1).

4.4.3.1 Working through logistics: Procurement, storage, retherming, service

A good understanding of the steps required for implementation of 3DPPF is necessary to capture potential logistical barriers as identified by RDs. Figure 4.0 displays a high-level process map which shows all the essential steps for offering 3DPPF to LTC homes residents as recommended by participants. Using the assumption that 3DPPF would be outsourced and brought into the home frozen, RDs identified potential barriers and considerations at every step of the implementation process, from procurement to service; these are also summarized in Figure 4.0.

Figure 4.0 High-level process map for the implementation of 3D printed pureed food in LTC



When speaking to the procurement of 3DPPF, RDs emphasized the importance of matching the foods with the regular food items in terms of composition, variety, and nutritional value in order

to meet ministry regulations and home standards. RDs described that, traditionally, pureed food is made by blenderising regular food items which ensures consistency in the food offered across textures: "*Yea, I was also thinking because the pureed food kinda resembles what is on the menu so I was thinking that if you buy a commercially prepared product, it would be different from what other people are actually getting."* (RD1, DG4). Cost was mentioned as another factor that is carefully evaluated when selecting menu items in LTC and it would therefore be of significant importance when considering procuring 3DPPF. Once and if 3DPPF is ready for mass distribution, it would be necessary to decide on a price within LTC homes' capacity for purchase; this would promote uptake of these products by the homes: "*And also likely the cost would be an important piece of information and driver for the product" (*RD2, DG3). Outsourced items like 3DPFF would be stored in a freezer until such time as they were required for use. RDs voiced a concern with storage capacity in relation to size of the home; whether it was the food volume or the size of the freezer, it was thought that storage would be an important area of concern which must be addressed in order to promote successful implementation.

With 3DPPF, retherming would be a new process in food service operations as traditional pureed food is usually prepared and served the same day. RDs revealed that the retherming process varies depending on kitchen design and equipment availability and therefore 3DPPF should accommodate such diversity:

> *So it sounds like we need to make sure that the product can be used in a variety of retherm environments, then obviously. So packaged in a way where it can be rethermed in various retherm environments so whether it be in an oven or in a well, heated well, steam bulk carts.* (HK, DG1).

As for service, 3DPPF would need to be packaged in such a way that makes it easy for dietary staff to determine the appropriate serving size. Individual portions would then be placed in shallow pans instead of the traditional bulk presentation in deep pans. Although this presentation method would be necessary to preserve the shape integrity of the products, it posed some concerns for RDs who were wondering "*do you have space at point of service to be able to serve it rather than taking a scoop and scooping it out?"* (RD2, DG1). Space availability on the plate was another service consideration as RDs thought that the dimensions of the carrot medallions presented in the video were particularly large and that the medallions should be resized "*to make sure there's enough room on the plate for your protein and your potato."* (RD2, DG2).

Efficiency and labour requirements were important considerations for successful implementation of 3DPPF as "*the ministry only allows a certain amount of money for staffing"* (RD1, DG3). It was thought that 3DPPF could improve the efficiency of preparing and serving pureed food as it omits some of the initial preparation and the IDDSI testing steps required for traditional pureed food. However, some of the procedural changes required to prepare, retherm, and serve 3DPPF may present some challenges with regard to efficiency in larger homes:

> *I mean we have a home that is 250 residents and 30% on pureed, or close to it. So that's a challenge. It's a bit different when you have a home of 45 beds and 1-2 puree.* (RD3, DG1).

Overall, RDs thought that the implementation of 3DPPF should be streamlined through a careful evaluation of food service procedures, equipment availability, and time and space requirements. They shared that it would be necessary to design a comprehensive implementation guide for staff

in order to ensure effective and successful uptake: *"Having a guide for staff and management that includes how to implement it, what equipment is required, best ways to serve it, etc."* (RD4, DG1).

4.4.3.2 Key considerations for creating a quality product

In addition to logistical issues, product quality and composition would greatly influence the ability to successfully implement 3DPPF in LTC homes. Key considerations brought forward by RDs were shape stability, ingredients, taste, and texture.

RDs placed great emphasis on ensuring that the products were able to hold their shape throughout the process required for service:

> *And if it came in already prepared, by a manufacturer, it would have to be something that would be able to hold on during freezing and when serving. So we would have to be able to transfer it into pans in the retherm carts* (RD2, DG2).

One RD reflected on her home's experience with the molded food and concluded that 3DPPF may need to be kept in its original package, or mold, throughout the retherming process in order to ensure shape stability:

> *One thing the manufacturer came up with is serving the food in a mold, you'd have turn it on a plate once the retherm cycle is completed. So it just maintains its shape and it comes out. I think anything out of a mold that you'd need to retherm would need to stay in the actual mold for the retherm cycle.* (RD2, DG2).

While the integrity of the product was placed high on the RDs' list of priorities, they stated that this should be achieved without adding a large amount of thickener or additional ingredients. They justified their reluctance from recommending such products by reflecting a desire to stay away

from highly processed food; they also described how large amounts of thickener could negatively impact the food texture and nutrient density. In one DG, RDs showed inclination towards in-house prepared products but seemed to be open to commercially prepared foods as long as these were minimally processed:

> *RD2, DG1: My biggest criterion is the taste of the food and the ingredients. So very often, the pureed foods we purchase now have many additives to maintain their shapes. It is very different from in-house production where we can use very few additives that are known to us.*

> *RD4, DG1: I would agree as this would steer us away from making homemade food, which are preferred by residents.*

Although RDs were not in favor of using large amounts of thickener for pureed food production, they acknowledged that some food items required such additions in order to yield consistent products. Macronutrient and water content seemed to play an important role in the integrity of various foods; for example, vegetables and salads become very watery when pureed due to their high water content while carbohydrate-containing foods such as pastas and muffin tended to become runny or sticky and unappealing. Mixed meals were also an area of concern as RDs were not sure how these would be produced through 3D printing. These concerns with variety should be taken into account when evaluating workability of 3DPPF as it would be optimal to provide a wide variety of standard and mixed products to meet LTC homes' needs and assist in improving the acceptability and appeal of pureed food.

4.4.3.3 Piloting with staff, residents, and families

Before products like 3DPFF would be accepted for use in LTC, theywould need to be trialed with the staff, residents, and families, as these are the individuals who would be most affected by such changes in the food service operations and distribution systems. Their perspective and feedback would ultimately be the best guidance for any future plans of implementation: "*Regardless of whatever happens, any new items would have to go through the food/resident council."*(RD2, DG3).

As well, RDs described that it would be necessary to demonstrate the efficacy of products: *"And also, you would trial it and see if it does improve the residents' intake…just to see if it actually impacts them."* (RD1, DG4). As with any quality improvement project, stakeholder involvement during this trial period would be a must; RDs recalled specific instances where staff, residents, and/or families' support of or resistance towards specific initiatives affected the success of the projects. Using the example of introduction of molded pureed, the importance of staff buy-in to successful implementation was explained:

> *RD2, DG1: We tried to bring forward the molds with our cooks and they said it's too time consuming.*
>
> *RD1, DG1: We have them made by our dietary aides and it's been more accepted by staff. It's an initiative that we brought forward a year ago and it seems to be effective.*
>
> *RD3, DG1: We also tried doing the molds and it has been effective because it does look closer to the real food. We are in the early stages of using the food molds and I think overtime we will find out how we can streamline the process so we get buy-in from the staff.*

Therefore, when planning to create a user's manual for 3DPPF as suggested in one DG, it would be crucial to consult with food service team members for effective and successful concept design and implementation.

4.4 Discussion

Research involving the participation of RDs specializing in geriatrics care is very scarce; this is one of the very few studies exploring RDs' perspective on a food-related intervention in LTC. It is also the first study evaluating RDs' perception on 3DPPF as an alternative to traditional types of pureed food in LTC. The RDs who participated in this project demonstrated advanced knowledge in the LTC setting and most of them were at the proficient or expert level in geriatrics nutrition as described by Robinson & Cryst (2018). They offered an in-depth analysis of the benefits, limitations, opportunities, and considerations for 3DPPF in LTC by discussing issues beyond resident-level factors. Since the participating RDs were intimately involved in nutrition care through their active involvement in the implementation, organization, and management of nutrition programs, they were able to provide a perspective on operational and procedural considerations for the implementation of 3DPPF in LTC homes. They acknowledged the importance of conducting resident-centered global assessments while factoring in individual needs and environments to determine the best-suited strategies for recommending and offering pureed food to residents.

In this study, RDs described the complexity of prescribing a pureed diet by outlining the steps required to identify risk factors necessitating such diet orders. In using the Nutrition Care Process (NCP), RDs conduct a holistic assessment including objective and subjective data gathering to guide their recommendations for any nutrition intervention, including modified texture diets

(Hammond, Myers, & Trostler, 2014). The specific approaches discussed with regard to dysphagia management in this study necessitated critical thinking, collaboration, and communication to assist residents and families in *weighing the risks against the benefits of a pureed diet*. Similar strategies were highlighted by Keller & Duizer (2014c) whereby team members from various disciplines rationalized the use of pureed diets by describing their firm belief in promoting and advocating for residents' safety and nutritional health. While such recommendations are based on the core value of beneficence, they may not always be consistent with residents' preferences and choices. Therefore, residents may decline nutrition recommendations and choose to live with the health risks associated with their refusal. This concern was identified by RDs in our study and is consistent with findings from previous work (Keller & Duizer, 2014c; Blaise, 2010; Cassen, Johnson, & Keelan, 1996), which revealed that there is frequent refusal of pureed diet prescriptions due to the poor visual appeal and inconsistent texture of the food.

In order to overcome the issues of poor visual appeal, RDs discussed many strategies including molded, or pre-shaped, pureed food and some shared experiences where this intervention was effective in improving the mealtime experience. However, previous work has demonstrated limited benefit of this pureed food production technique in enhancing the quality of pureed diets (Stahlman, Gracia, & Hakel, 2000; Lepore et al., 2014). In their study, Stahlman, Garcia, & Hakel (2000) compared the appeal of traditional and molded pureed peaches and found no improvement in participants' liking of the food items when presented in molded format. In considering the scarcity of evidence regarding the best approach to improve the quality of pureed food, RDs were open to considering novel strategies such as 3DPPF to help *sell pureed food to residents and families*. Particular emphasis was placed on improving the appeal of some "problem pureed foods" such as salad, carbohydrate-rich foods, and cold plates, as these proved to be more difficult to

puree. It may therefore be a beneficial initial step for 3DPFF to target these foods first due to the potentially higher need for and desirability of such products; this need to find solutions for "problem foods" was also identified by Anciado, Ilhamto, Keller, & Duizer, (2012). Theyrevealed that nutrition managers in LTC were more likely to purchase commercial pureed products for food items that are hard to puree in-house. In having such foods available in a more desirable format, pureed food consumers would have a wider variety of appealing food products to choose. The availability of such products would also resolve the issues of lack of variety in traditional and commercial pureed food products which was identified in our study and reiterated by Keller & Duizer (2014c).

While sensory attributes were difficult to navigate and improve, nutritional value was an issue that seemed to be easily solvable through creativity and innovation; for example, RDs thought that fortifying 3DPPF with vitamin, minerals, and isolated protein powders would improve the nutritional quality of the pureed diets. The idea of fortification was a major selling point that RDs identified to enhance the appeal and uptake of 3DPPF products. This suggestion for fortification of 3DPPF is supported by research which shows that patients and residents with dysphagia or those who consume a pureed diet are at high risk for malnutrition (Dahl, Whiting, & Tyler, 2007; Vucea, 2017a; Vucea et al., 2017b; Bocock, Keller, & Brauer, 2008). One study aimed at evaluating the effect of fortifying pureed food on residents' intake and serum biomarkers demonstrated benefits to residents (Adolphe, Whiting, & Dahl, 2000). The study also showed effectiveness of the intervention in treating vitamin D and folate deficiencies, but found that minerals were not acceptable for fortification due to taste alterations. In this light, 3DPPF may be supportive of residents' health and nutritional status if the product offers nutrient dense foods through fortification methods.

Product consistency was another quality measure discussed by RDs who admitted that their homes are not always able to meet nutritional and texture standards. They shared that attention to consistency will be heightened with the recent advances in research and clinical applications pertaining to dysphagia management and treatment. One such advancement is the use of the International Dysphagia Diet Standardization Initiative (IDDSI) which was developed in 2015 and is now being implemented in health care facilities across Canada (IDDSI, 2016; Piera & Rioles, 2019). The IDDSI framework calls for changes in the traditional and inconsistent nomenclature and testing methods used for modified texture foods and thickened fluids. Guidelines for preparing and testing foods and fluids based on a pre-set food texture and fluid consistency are provided within the framework (IDDSI, 2016). It is still unknown whether IDDSI implementation would be supported by current food pureeing methods or if novel and innovative alternatives such as 3DPPF are required to help with the transition. Previous work from LTC homes in New Zealand showed that pureed foods tend to comply with IDDSI standards while soft and bite-size foods do not meet the pre-set requirements by IDDSI (Miles et al., 2018). In our study, RDs' accounts revealed that there is potential for 3DPPF in helping with the transition to IDDSI given that this technology yields consistent products. Such foods could help close the gaps between theory and practice and assist with IDDSI implementation in LTC homes.

Beyond the resident-level and food specific factors, particular emphasis was placed on operational and procedural issues pertaining to the implementation of 3DPPF in LTC. Since the mealtime experience is affected by multi-level factors as demonstrated by Keller et al. (2014a), it is justifiable that RDs thought that the workability of 3DPPF in LTC is conditional and affected by many home-level factors. Specific attention regarding cost, storage capacity, staffing, equipment, and time constraints were thought to be major considerations to *finding solutions that are*

workable. Previous work by Ducak & Keller (2011) revealed similar limitations to changing the types of foods offered in Ontario's LTC homes; in their qualitative study, the authors identified issues relating to labor, food cost, and time constraints as being the major barriers to moving towards more resident-centered menus. Another study specifically aimed at evaluating dietary mangers' perspectives on commercially prepared pureed food revealed some of the same operational and quality barriers identified in our study, including time and cost concerns, freezer capacity, and the MOHLTC requirement to match regular texture menu (Anciado, Ilhamto, Keller, & Duizer, 2012).

Due to the many operational concerns associated with the production and service of 3DPPF in LTC, RDs thought that a trial period would be required to help decide if this is a viable option in their homes. They advocated for active involvement of team members, residents, and families in the process; this type of participatory involvement is supported by evidence-based practices for effective program design and implementation and should therefore be prioritized if 3DDPF is to be considered in LTC (Straus, Tetroe, & Graham, 2013). Additionally, by involving staff in the process, RDs would have an opportunity to gain a deeper understanding of team members' attitudes towards the pureed diet, which seemed to be negative according to RDs' accounts. Likewise, team members would also have a chance to ask questions about pureed food in general and 3DDPF in particular. This collaborative approach to project implementation would enable knowledge sharing and information provision to team members which are key component to providing effective resident-centered nutrition interventions as identified by Murphy, Holmes, & Brooks (2017).

4.5 Limitations

The small number of participants limited our ability to conduct formal focus groups; we instead used a small discussion group format to solicit RDs' perspective on 3DPPF. Additionally, it is unlikely that we have researched data saturation as the number of participants and DGs was very small however it is worth noting that data saturation could be achieved with as little as 6 interviews in applied research studies (Green, Thorogood, 2014). Finally, the unavailability of product information limited RDs' ability to provide a comprehensive assessment of 3DPPF; instead they shared some potential, not actual and current, considerations and concerns associated with these products.

4.6 Conclusion

This is the first known study that has explored RDs' perspective on a specific food-related intervention aimed at improving the quality of pureed food in LTC homes in Ontario. The results from this study will help in developing 3DPPF that meets RDs expectations for LTC homes. Additionally, the results could be extrapolated to other, similar, interventions to help improve the quality of the food in general and pureed food in particular, in LTC. The descriptive thematic analysis identified that RDs favored an intervention that would help decrease the risks associated with a pureed diet while maximizing its benefits. They were also seeking a good quality product to help convince residents and families to accept a pureed texture prescription. By improving the sensory attributes of the food, stigma around pureed food may be removed. Finally, while RDs were excited about 3DPPF, they wanted to ensure that the technology is workable withinthe LTC context and that it fits into the current food service operations system. They described several areas to consider as well as strategies to promote acceptable products.

Chapter 5: Part 2. Manuscript 2: Residents' and Family Members' Perspectives on the Potential for 3D Printed Pureed Food in Long-Term Care Homes

Unsubmitted Manuscript

Background. Pureed diets often lead to an increased risk of malnutrition and this may be due to their poor sensory properties. LTC homes are therefore constantly seeking ways to improve the quality of pureed food in order to prevent malnutrition and increase residents' satisfaction with the food and the mealtime experience. Interventions such as food molding and piping and commercial-prepared shaped pureed products are available to LTC homes however the effectiveness of these interventions is unknown and there is mixed evidence about their acceptability. This study aims at exploring the potential and acceptability of a novel product, namely 3D Printed Pureed Food (3DPPF), based on residents' and family members' perspectives.

Methods. This was a qualitative study with an interpretive description methodology. Purposive sampling was used to recruit residents and family members from five participating homes. A total of 10 participants (2 family members and 8 residents) were recruited for individual interviews (I=10). A semi structured interview guide was used to help understand residents' and family members' perspectives on 3DPPF as an alternative to current types of pureed food offered in their homes. Verbatim transcription was done by the first author for all interviews. Transcripts were coded line-by-line and meaningful themes identified by the first author and confirmed by the senior author.

Results. Two over-arching themes emerged from the qualitative data. Above all, residents and family members valued residents' satisfaction with the food and described that it would be

necessary to ensure that 3DPPF could offer an enjoyable dining experience to pureed food consumers. While they were excited about 3D printing technology, participants identified that implementation could be challenged by resource limitation and time constraints.

Discussion. Residents and family members described that the traditional pureed food is not appealing in terms of presentation, texture, and taste. They stated that an enhanced product, such as 3DPPF, could help improve residents' dining experience and food intake. While the 3DPPF products looked appealing to participants, they described that they would not be able to provide a comprehensive assessment until such time that they could evaluate other important sensory attributes of the food, such as taste. Residents and family members showed enthusiasm about 3D printing technology for pureed food but acknowledged that procedural and resource limitations could hinder applicability within the LTC context.

Conclusion. The quality of pureed food could be enhanced with 3D printing technology and this may help improve residents' food intake and their dining experience. However, contextual evaluation and staff solicitation and collaboration should be undertaken prior to implementation in order to ensure that this novel product fits within the LTC context.

5.1 Introduction

There is a growing interest in improving the quality of the food offered in LTC as regulatory bodies and public health authorities begin to recognize the impact that food has on residents' quality of life (Byles et al., 2009; Dietitians of Canada, 2019). In fact, the most recent *InterRAI Quality of Life Survey* contains a specific domain comprised of 5 items dedicated to residents' satisfaction with the food and meals offered in LTC homes (Heyer, 2017). Unfortunately, LTC homes aren't always meeting residents' expectations with regard to food quality; a Canadian cross-sectional study of 928 LTC residents estimated that only 66.1% enjoyed their food (Kehyayan et al.,2015). While these findings pose concerns for all LTC home residents, pureed food consumers are most vulnerable due to the reported poor sensory properties of pureed food products (Keller & Duizer, 2014b). In addition to negatively impacting quality of life, the poor appeal of pureed foods poses detrimental consequences on residents' nutritional status by increasing the risk of malnutrition, specially under nutrition (Dahl, Whiting, & Tyler, 2007; Vucea, 2017a; Vucea et al., 2017b; Bocock, Keller, & Brauer, 2008; Keller et al., 2012a). Specifically, the food is unrecognizable from a visual perspective (Keller & Duizer 2014b); it is not clear that the green food provided in a pureed texture is peas vs. broccoli.

In order to improve the quality of the pureed diet and to make it more acceptable, some homes use strategies such as molding and piping to enhance the visual properties of the food. However, research shows mixed results with regard to the efficacy of such techniques in improving residents' liking of the pureed food (Germain, Dufresen & Grey-Donald, 2006; Lepore et al., 2014; Stahlman, Garcia, & Hakel, 2000). This paper explores the potential of a novel and innovative food product, namely 3D printed pureed food (3DPPF), in improving the appeal of pureed food by offering food items that look like the food from which they were derived by being re-created into a recognizable

shape. At this time, there is very little research on consumers' perception of 3D food printing in general and no research that is focused on consumers themselves; this study explores residents' and family members' perspectives on the visual appeal, benefits, concerns, limitations, and usefulness of 3DPPF for pureed food consumers in LTC. The objective is to determine if, from the perspective of these stakeholders, this novel food technology has sufficient benefits to warrant continued development and further testing in this health care sector.

5.2 Methods

5.2.1 Overview

This was a qualitative descriptive study with an interpretive, inductive thematic analysis that examines perspectives of residents and family members, dietary team members and dietitians. Five Ontario LTC homes that were part of the researchers' network were purposely sampled and invited to participate in the study. The LTC homes included in this studyrepresented a variety of business-models (for-profit and not-for-profit). All homes confirmed use of pureed food for residents; details about the types of pureed food offered at the participating homes are provided elsewhere (This information will be included in the team members paper and it should therefore be cited here, from the various publications). Only the analysis based on residents' and family members' perspective is presented here.

5.2.2 Participants

Residents and family members were recruited using purposive and intensity sampling with a focus on acquiring knowledge from information-rich participants, who were at least somewhat familiar with pureed food through direct experience or indirectly, through exposure in the dining room

(Patton, 1990). As many residents who require pureed food are unable to communicate verbally (Keller & Duizer, 2014b), participation was not limited to this group. All residents were eligible to participate in the study regardless of cognitive status, as exclusion of residents with cognitive impairments could not be justified and would not be socially just (Lepore, Shuman, & Wiener, 2017). Residents and family members were recruited with the assistance of gatekeepers from the five participating homes. A total of 10 participants, 8 residents and 2 family members, were included in individual, in-person, interviews.

A demographic questionnaire was completed by participants at the beginning of each interview. Table 5.0 provides a detailed description of participants. The majority of participants were residents, with two family members participating to represent their loved ones' experience with pureed food. Most residents (60%) who participated or were represented in this study were living in the home for at least one year. Only one of the participating residents received a pureed diet while the majority (6 out of 8 participating residents) received regular food.

Table 5.0 Participant Information for residents and family members (n=10)

Demographics Information		Participants n (%)
# of residents		8 (80%)
# of family members		2 (20%)
Gender	Female	4 (40%)
	Male	6 (60%)
Age (Range)	60-70	3 (30%)
	70-85	4 (40%)
	85+	3 (30%)
Time in the home	< 6 months	2 (20%)
	6 months – 1year	2 (20%)
	1-3 years	4 (40%)
	3-5 years	1 (10%)
	> 5 years	1 (10%)
Resident's diet order	Pureed diet	3 (30%)
	Minced diet	1 (10%)
	Regular diet	6 (60%)
Familiarity with puree diet for residents who didn't receive pureed	Most of the residents who didn't receive a pureed diet had some exposure to pureed food. They did not have deep knowledge or understanding on other people's experience with the pureed diet but had seen it being served to co-residents in the dining room. The type of pureed food offered to residents was the traditional scooped pureed. One resident had a previous experience with molded pureed food.	

5.2.3 Data Collection

Interviews were semi-structured, individual, and conducted in person by one researcher. The duration of the interviews varied between 5 and 13 minutes depending on participants' engagement which was impacted by cognitive abilities and capacity to communicate. The interview structure included four distinct parts; the first focused on gaining some understanding on participants' familiarity with the pureed food as well as their opinion of the pureed diet in general. The second part was a picture-based photo elicitation whereby participants were shown different types of pureed food (scooped, molded, 3D printed), then asked specific questions with regard to appeal, preference, and distinguishability of the food items. The third part of the interviews was an

introduction to 3DPPF through a researcher-developed video presentation of pureed carrot medallions. This was followed with specific questions geared towards understanding participants' perspective on 3DPPF including potential benefits, limitations, and concerns. Throughout all interviews, participants were encouraged to ask any questions or offer any comments as needed. The specific questions included in the interviews were based on the interview guide (table 5.1). All interviews were audio-recorded and verbatim transcription completed by two researchers, SA and VT.

Table 5.1 Interview guide for residents and family members' interviews

Structure of the Interview	
Part 1 *Understanding residents' and family members' familiarity with a pureed diet*	<u>If resident receives pureed:</u> How would you describe your food? What do you like about it? What do you like less? <u>If resident does not receive pureed:</u> Do you know anyone in this home who receives pureed food? What do they tell you about it? What do you think of it?
Part 2 *Photo-elicitation of different types of pureed food to explore residents' and family members' perspectives*	What foods do you see on these pictures? Which one of these look the most appetizing to you? Which one looks less appetizing? If you had a choice between all three, which one would you pick? Do you have any ideas on how to improve pureed food?
Part 3 *Video presentation of the production process of 3DPPF*	*Introduction to 3DPPF though video presentation and narration of production process (food used in video: pureed carrots shaped into medallions with the 3D printer). The video provided a presentation and description of: 1) the food pureeing process and environment, 2) the 3D printer and the printing process, 3) the steps of storing in a freezer and retherming in a conventional oven, and 4) the presentation of 3D printed pureed food on the plate.*
Part 4 *Exploring residents' and family members' perspective on 3DPPF as an alternative to pureed*	What do you think of this way in making pureed food (in reference to 3D printing)? What do you like about it? What are some things that may worry you about food if it's made this way? What else would you want to know about this type of pureed food?

5.2.4 Data Analysis

All interviews were analyzed by one researcher (SA) and member checked by the senior author (HK) at every step of the analytical process. Thematic analysis was completed and the coding process was informed by grounded theory which calls for the application of several levels of coding (Thorne, 2008). In this study, open and axial coding were used to develop themes; open coding is applied first and it consists of fracturing of the data to examine similarities and differences. This is followed by the identification of axial codes to connect and categorize the textual fragments (Thorne, 2008). A constant comparison technique was applied to help uncover commonalities across participants' accounts (Thorne, 2008). All coding was done manuallyusing Word Processor 2010.

Once coding was completed and codes were reviewed and confirmed by HK, meaningful and useful themes and sub-themes were identified by grouping codes that represented similar ideas. Thematic memos were developed based on the proposed themes, sub-themes, and potential quotes supporting each theme. These were then reviewed by HK who provided feedback and recommendations for revision. A final copy of the thematic memos was then drafted, and with editing, became the results for this manuscript.

5.2.5 Ethics and consent to participate

Ethics approval was obtained from the University of Waterloo Research Ethics Board (ORE#31978). Participants provided informed written consent to participate in the study. A verbal reminder regarding the ability to withdraw at any time was provided at the beginning of each interview. Participants were aware that some of the quotations would be used in the dissemination of this work and that these would be de-identified.

5.3 Results

In this study, residents and family members expressed varying levels of satisfaction and acceptability of pureed food. For some, reshaping techniques were perceived as a necessity while for others the provision of shaped food products through 3D printing was not necessary, but certainly an added benefit. Two major themes emerged from the interviews. It was thought that ensuring that residents were happywith their pureed food was a priority; participants talked about factors that influence satisfaction with the pureed food, including residents' characteristics, and the taste and visual appeal of pureed products. Although residents and family members were fascinated by the innovation of 3D food printing, they expressed some concerns with regard to feasibility within the LTC context.

5.4.1. Ensuring that the residents are happy with the food

Whether it was through self-advocacy or advocacy for others, residents and family members portrayed strong feelings towards the importance of ensuring that residents are happy with their food. One family member expressed gratitude when describing her loved one's satisfaction with and acceptance of the pureed food *"it's just such a… we're so thankful because she seems to enjoy eating for the most part. She never complains."* [Participant 4 Site 3(P4S3): Family member]. Residents' satisfaction with the meals was thought to be first and foremost influenced by the resident's characteristics and by the taste of the food. Additionally, participants shared that enhancing the visual appeal of the food may also increase residents' satisfaction. Resident-level factors such as cognitive function, vision, communication abilities, and appreciation for the need of a pureed diet were major drivers for perceived residents' satisfaction with and/or acceptanceof the pureed food. Family members of residents with cognitive, vision, and/or communication

impairments seemed to be highly involved in the mealtime process and proactive in asking about likes and dislikes; they communicated with their loved ones through nominal and/or non-verbal means to capture food choices and to assess their enjoyment of the food: "*Yea so then I know she doesn't like the food {when she scrunches up her face}"* [P1S3: Family member]. They also gained an understanding of residents' acceptability of the food through behavioral observation; as such, they linked acceptability of eating to enjoyment of the food: "*The only thing, the scrambled egg they bring in. One morning she will eat it, the next morning she doesn't like it."* [P1S3: Family member]. By evaluating residents' choices, likes, and dislikes, family members felt capable of assisting residents in selecting the appropriate types of food to ensure that residents were happy with their meals: *"Sometimes she looks at two different plates, she looks at them and I tell her I am getting this and she would pick the same."* [P1S3: Family member]. Family members' evaluation of residents' enjoyment of the food revealed that residents with significant functional impairments (cognition, vision and/or communication) were usually satisfied with the pureed food despite its poor visual appeal **"***Yea. So vegetables are sometime just a ball of green. But she eats it, she eats it. She's not a fussy eater."* [P1S3: Family member]. These residents were thought to be *"easy and happy with food"* [P4S3: Family member], they were neither demanding nor particular with their food:

> *She is legally blind. So she's not able to see what she's getting. And she's not a complainer... Because I knew this was happening I asked her yesterday "How are your meals here?" and she said "Good!" So I mean they probably are good but I wonder what she'd say if she was able to see them* [P4S3: Family member].

Although their loved ones were satisfied with the pureed food, when reflecting about their own perspective of the food, family members expressed a desire for visually enhanced products to improve residents' mealtime experience:

> *I think if she was able to see what she has and cognitively able to know what food she has, she would be quite happy with this {3DPPF}. To be eating something that is shaped, more than this {traditional puree}* [P4S3: Family member].

In contrast, residents with no or minimal cognitive, vision, and/or communication impairments were described as preferring a regular diet over the pureed texture. Participants recounted instances in which co-residents refused their pureed food, *"They just say no"* [P2S1: resident] or were envious of their tablemates' regular food and asked to receive the same, *"They say give me the other one"* [P2S2: resident]. This refusal and dislike was equally expressed in the context of molded pureed food which was described by a resident as being "*Disgusting. Absolutely"* [P4S5: resident]. The resident further added that she disliked everything about the food including the texture, the look, and the taste. While a pureed diet was thought to be a diet of necessity and while some were content with it: "*And once it was pureed, it didn't matter which one I had."*[P3S2: resident], accepting it as a permanent diet option proved to be more difficult and residents were wondering if they can ever eat "normal food" again: *"can I ever graduate back to my normal diet?"* [P6S2: resident].

Normalizing the pureed food was highly desired by participants, particularly for residents withno or minimal functional impairment. When introduced to 3DPPF, residents and family members thought that it may be an effective strategy to improve the meal quality by offering foods that

resemble their natural shape. They noted that the ultimate goal was to ensure that pureed food consumers were happy with the food and were enjoying their mealtime experience:

> *I wish you a lot of success {telling the researcher about the 3D printed food project}. Because as I notice, my neighbor has to get pureed food and when I get my {regular texture} food he says "Ohh I like these".* [P2S2: resident]

In addition to resident-level characteristics, taste was thought to be one of the major drivers for residents' satisfaction with the food*: "Well when I assess food, I look at a couple of the things. One, does it look good? Two does it taste good?"* [P2S2: resident]. The taste of the pureed food was described as being *"awful"* [P4S5: resident], *"sometimes sweet, sometimes blablabla, and sometimes in between"* [P3S2: resident], or not very flavorful. The one resident who received molded pureed food thought that the food tasted *"like cardboard"* [P4S5: resident]. These descriptions of the taste of pureed food reveal that there is an obvious necessity to work on improving its flavor profile. When asked about their opinion on 3DPPF, participants were reluctant to offer a comprehensive perspective about the concept as they had some reservations towardsthe taste. One resident summarized the general sentiment towards 3DPPF: *"So I don't know… Idon't really have a comment. I mean it looks great. Will it taste good once it's all said and done? We don't know, nobody really knows"* [P4S5: resident].

The look of the traditional pureed food was unappealing to residents and the food was described as looking like *"Mush"* [P4S5: resident], *"Kinda juice and kinda flat"* [P2S2: resident], and *"All water"* [P2S6: resident]. It was mentioned that the pureed food needs to be shaped better and particular attention should be placed on specific food items such as breakfast foods and sandwiches: *"But breakfast is the worst, it looks the worst. Like how do you do a sandwich?"*

[P4S3: family member]. In order to overcome the poor visual appeal of the pureed food products, residents compensated by opting for food items that were naturally pureed such as mashed potatoes and puddings: *"I love mashed potatoes… Mashed potatoes and gravy, and it is already pureed."* [P3S2: resident]. None of the participants provided a positive description of the look of traditional pureed food and when asked to make a selection between the different types of pureed food, participants always selected shaped products (either molded or 3D printed) over the traditional scooped pureed. The following exchange represents responses provided when participants were asked to make a selection between shaped and traditional pureed food:

> *"R: So out of these three pictures, which one looks most appetizing to you? P3: [pause] probably this one. R: The molded one, okay. Which one looks the least appetizing to you? Let me show you this first one again. P3: That one. R: The first one. The traditional pureed"* [P3S1: resident].

Shaped products were also more recognizable than the traditional pureed foods which were often indistinguishable*: "I usually find it difficult to identify the {traditional pureed} food that is put on my plate; I usually need a description to tell me what I am eating. I never know what it is."* [P3S2: resident]. While molded foods were almost always distinguishable for residents, 3DPPF posed some confusion; some residents instantly recognized the carrot medallions while others had some difficulty identifying them: *"You know, I don't know what that is (3DPPF picture). I think this actually looks even better (molded food)."* [P4S5: resident]. Despite the distinguishability issue of the 3D printed pureed carrots, participants liked their color and thought that they were *"kinda nice looking"* [P1S2: resident]. It would therefore be necessary to improve the shape of 3DPPF in order to maximize benefits to residents by increasing recognition of food items.

5.4.2. Appreciating novelty while acknowledging potential limitations

When introduced to 3DPPF, residents and family members expressed enthusiasm and excitement about the technology; they thought that it was a cutting edge strategy to improving the appeal of pureed food. However, there were some reservation towards applicability, safety, and food quality. Additionally, the process of making 3DPPF seemed to be unclear for some residents despite viewing the video presentation.

After watching the recorded video of the making of 3D printed pureed carrots, residents and family members were asked to give their opinion on this novel approach to making pureed food. There was a prevailing sentiment of excitement and amazement with the technology: *"Wow she's printing food?... It's very unusual. I would have never thought of it. I wouldn't have even though it's even possible."* [P3S2: resident]. Participants stated that they would be proud to have 3DPPF served to the residents who need it; one resident described that this novel product would normalize food for pureed food consumers: *"I think it's an exciting discovery really. For those of us needing it (...) takes it one step closer to the normal way."* [P6S2: resident]. Residents also shared some ideas to maximize usefulness of the technology: *"Maybe they could try making it with other kinds of food…different vegetables; broccoli, cauliflower, parsnips, peas. "*[P1S2: resident].

While the concept was thought to be exciting, the process of making 3D printed pureed carrots seemed rather confusing and participants asked for further clarification regarding the pureeing and printing steps required to make 3DPPF. They also inquired about applicability with other types of food:

> *So when they get the stuff, the carrots into the syringe, how do you make the carrot like that?* [P1S2: resident]. *How do they do meat…Cause I find the meat not cooked enough.* [P3S1: Resident]

The texture and consistency of the shaped products was also a concern as there was some skepticism about the safety of 3DPPF: *"Oh she couldn't eat that…. If you cook a piece of that, it would break up wouldn't it?"* [P1S3: Family member]. Transparency about food safety and product origin would also be required as one family member described that such information would drive product acceptability:

> *I'm sure it's all clean. The equipment would have to be clean and knowing where it's coming from. And probably knowing the carrots aren't coming from who knows where. That's probably one concern I would have. Ummm otherwise, yea looks great.* [P4S3: Family member].

Suppliers would also need to ensure that the products are satiating and satisfying as this would allow researchers, dietitians, and caregivers to confidently answer residents' inquiries regarding hunger and satiety when they ask: *"Will it fill me up?"* [P3S2: resident].

In addition to food quality, participants were concerned about the applicability of 3D food printing technology within the LTC context. The cost of the equipment was brought forward as a concern; the viability of 3DPPFF was thought to be dependent on cost and efficiency. By assuming that the food would be produced in-house using a 3D printer, participants described that producing one serving of carrots in 16 minutes would be very time consuming and most likely unrealistic in LTC. Despite the seemingly impractical implementation of 3D food printing in LTC homes at this point,

residents thought that it is an interesting concept and advancement in the technology and/or changes in the process may promote applicability:

> *P2: Seems like you have to do a lot of stuff to get them the way you want (in ref to 3D printed puree). (...) R: So imagine having to feed 90 people; that would take a long time. SO there is still a long way to and we're not quite sure about it but… P2: But that's how we make improvements I guess.* [P2S2: resident]

5.4 Discussion

This is one of the very few studies (Keller & Duizer, 2014b; Blaise, 2010; Colodny, 2005; Stahlman, Garcia, & Hakel, 2000; Germain, Dufresne, & Grey-Donald, 2006) evaluating older adults' and/or their family members' perspectives on pureed food and their opinion about specific interventions aimed at improving the quality of pureed food. While previous work evaluated consumers' perceptions of 3D food printing as a general concept (Brunner, Delley, & Denkel, 2017; Lupton & Turner, 2016), this is the first study to explore the usefulness of this innovation for a specific target consumer group, namely older adults living in residential care who require pureed food for health and therapeutic reasons. Our study reveals that improving the sensory qualities of pureed food would most benefit residents with no or minimal cognitive, vision, and/or communication impairments, as this group seems to have a higher tendency to dislike and/or refuse the pureed food. Similar findings were noted by Simmons, Cleeton, & Porchak (2009) who showed that cognitively-well residents had more complaints with the food served in nursing homes than residents with cognitive impairments. However, it is important to acknowledge the significant barriers in understanding the true perspective of residents with cognitive impairments; these individuals are often represented by care providers or family who may relay an incomplete or

inaccurate reflection of residents' actual lived experience (Bamford & Bruce, 2000). In ourstudy, residents with functional impairments were represented by familymembers who were involved in the mealtime process and who evaluated residents' enjoyment of the food based on their family members' acceptance of it. However, acceptance may not always imply satisfaction as shown by Evans & Crogan (2005), who found that 65% of residents in their study did not complain about the food even when it was not appealing to them. In addition to residents' perceived enjoyment, when working towards an intervention aimed at *ensuring that residents are happy with the food,* it is important to consider families' and caregivers' perspectives of the food. In our study, family members of residents with cognitive impairments talked about the poor visual appeal of a pureed diet and projected a desire to improve their loved ones' food quality and mealtime experience. Similar accounts were revealed by family members included in a qualitative study by Keller & Duizer (2014b) who also sought innovative improvements in the pureed food by elaborating on its poor visual presentation, lack of consistency, and the limited variety in the pureed diet. These findings reveal that an improvement in the quality of pureed food is required for all residents. Such a quality initiative would not only improve quality of life and enjoyment of the meal, which were prioritized by our study participants, but it may also improve nutritional health and intake for all residents regardless of cognition or functional abilities (Germain, Dufresene, & Grey-Donald, 2006; Crogan, Short, Dupler, & Heaton, 2015).

Our study reiterates findings from previous work (Keller & Duizer, 2014b; Blaise, 2010; Keller et al., 2012a), whereby taste was identified as the most important sensory attribute of pureed food. Similar to accounts provided by Blaise (2010), our study participants thought that the traditional pureed food tasted awful and was flavorless. Residents and family members interviewed by Keller & Duizer (2014b) offered a more nuanced description of the taste of the traditional pureed food by

indicating that pureeing food products and potentially adding thickeners changed their flavor profile, which made it difficult to distinguish foods based solely on their taste. Molded foods were also described unfavorably in our study and were thought to taste "like cardboard"; similar descriptors of molded and commercial products were provided in previous work whereby the use of additives or binding agents resulted in significant compromise in taste, texture and/or mouthfeel (Keller & Duizer 2014b; Anciado, Ilhamto, Keller, & Duizer, 2012; Kennewell & Kokkinakos 2007; Cassens, Johnson, & Keelan, 1996; Stahlman, Garcia, & Hakel, 2000). These findings reveal that a minimal amount and appropriate types of additives and/or thickener should be used in the processing of 3DPPF in order to offer quality products by preserving taste and mouthfeel. If and when such products are ready and safe for consumption, a taste-test would be required prior to product implementation in LTC. This would promote product acceptability and decrease concerns with the production process (Lyndhurst, 2009). Until such time, it would not be possible to fully evaluate the potential uptake of 3DPPF by LTC residents as participants displayed significant reservations towards taste, which was identified as the main driver for acceptability.

Appearance was the second most important sensory attributes identified by participants as they thought that *improving visual appeal would improve satisfaction with the pureed food.* Consistent with previous work (Keller & Duizer 2014b; Colodny, 2005; Blaise, 2010), the traditional pureed food was thought to be "mush", shapeless, and requiring more color/vibrancy. Although this study does not offer a comprehensive understanding on how the poor visual appeal of pureed food negatively affects residents both psychologically and emotionally as described by Keller & Duizer (2014b) and Colodny (2005), it touches on the concept of jealousy experienced by residents when they are exposed to the more visually appealing foods offered to their tablemates. The poor appeal of the pureed food and the negative experiences associated with a pureed diet prescription are some

of the motives and reasons for advocacy towards improving the visual presentation of pureed foods through food molding and piping techniques (Alexis, 2003; Byles et al., 2009; Dietitians of Canada, 2019). While the evidence regarding the effectiveness of such interventions is very limited, some studies showed promising benefits on nutritional health, meal experience, and quality of life (Alexis, 2003; Germain, Dufresene, & Grey-Donald, 2006; Cote, Payette, & Gagnon, 2017). Similarly, our study participants advocated for normalizing the appearance of pureed food for consumers and thought that such strategies would improve their mealtime experience. This was further demonstrated by participants' selection of shaped products over the traditional scooped pureed during the photo-elicitation exercise.

While the preference for shaped products is inconsistent with previous work (Stahlman, Garcia, & Hakel, 2000; Lepore et al., 2014), it is important to recognize that this difference might have been influenced by methodological variations between the studies. In our study, food assessment was solely based on one sensory attribute of the food, namely visual appeal, while the other studies allowed participants to evaluate multiple sensory characteristics of the food items, including tasting the foods. Should we have used a multi-sensory assessment method, a different perspective might have been presented, however this was not possible since 3DPPF is not yet safe for consumption. When comparing the two different types of shaped pureed products, most of our study participants displayed an inclination towards molded foods and thought that these were more distinguishable and more visually appealing than 3DPPF. In this case, another methodological bias in the presentation of variety might have swayed participants' liking towards the molded foods; the picture of molded food presented a variety of food items on a plate, while only one product, carrot medallions were provided in the 3DPPF picture. Since varietyis thought to be an important aspect of meal quality as described in our study and by others (Blaise, 2010; Keller & Duizer

2014b; Keller & Duizer, 2014c), participants' preference for the molded food might have been a result of the variety in the picture, rather than the actual shapes of the pureed food products. These factors reveal that the look of the food is multidimensional and 3DPPF should be produced in such a way as to satisfy all aspects pertaining to appearance in order to promote resident acceptability while meeting LTC homes' quality standards which focus on resident satisfaction, food variety, and visual presentation (Dietitians of Canada, 2019).

Interestingly and contrary to findings from other studies (Brunner, Delley, & Denkel 2017; Lupton & Turner, 2016), the attitude towards 3DPPF was rather positive in our study. Participants were fascinated by the technology and described ways in which it could offer a more enjoyable dining experience to pureed food consumers. Negative sentiments such as food technology neophobia and novel food neophobia, previously linked to 3D food printing (Brunner, Delley & Denekl, 2017), were not expressed by our study participants. The conceptual framework on acceptance of technology-based food innovations by Rontelap, Trijp, Renes, & Frewer (2007) could be used to understand the higher acceptance of 3D food printing in our study; in appreciating the perceived benefits and the social context in which the technology was presented, we could comprehend our participants' positive attitude towards 3DPPF. While previous work evaluating consumers' opinion of 3D food printing aimed at exploring the general sentiment towards the technology, our study evaluated its usefulness in overcoming food-related issues which were already recognized and/or experienced by our study participants. The perceived benefits were therefore more tangible and participants were more equipped to appreciate the usefulness and applicability of the technology in their daily lives. The normalization of technology-based innovations in LTC could also have shaped the attitude towards 3DPPF. In fact, the LTC sector acknowledges the importance of using innovations as a powerful tool in meeting residents' needs and improving their qualityof

life (Ontario LTC Association, 2018); this value is reflected in participants' accounts as they described various ways in which 3DPPF could improve residents' mealtime experience and quality of life.

Demonstrating the process of 3D food printing might also have played a role in shaping participants' attitudes toward this novel food by allowing them to formulate a more informed perspective on the product. While previous studies offered minimal information about theprocess of 3D food printing, our study provided a comprehensive step-by-step demonstration of the printing of 3D pureed carrots medallions. In a qualitative study by Lupton & Turner (2016) whereby participants were exposed to minimal information about the process of making 3D printed food, concerns about strangeness of the food and suspicion around food processing were highlighted. These issues were not stated by our study participants, potentially due to their better understanding of the 3D printing process through viewing the video. This level of understanding may have been influential in increasing the acceptability of 3D food printing as consumers have a tendency to respond more positively to food-related innovations when new information about the technology is provided (Lyndhursts, 2009). Although the knowledge translated about 3D food printing was more comprehensive than what has been offered in previous studies (Brunner, Delley, & Denkel 2017; Lupton & Turner, 2016), our study participants sought more information about 3DPPF and were sometimes confused by the process of making the food. Specific information regarding nutritional content, descriptors of texture, food safety, origin of food products, and ingredients was requested by residents and family members. In fact, there was some skepticism about the safety of 3D printing technology in term of texture and foodborne illnesses and there were some concerns about the origin of the food. In order to address such apprehensions, it would be necessary for the food supplier and LTC homes' personnel to be transparent about thecooking

and preparation process; including adherence to the pureed texture requirements. It would also be important to attend to residents' and family members' concerns and questions around food safety, food origin, and food composition in order to promote informed decision-making regarding acceptability while promoting uptake of these products by residents and family members.

While the innovation was overall acceptable to our study participants, its applicability within the LTC context was rather questionable. Although 3D food printing is marketed for its potential in offering foods quickly and easily (Lupton, 2017), the process of printing the carrot medallions was thought to be lengthy, complicated, and potentially costly. Previous work demonstrated similar barriers to the implementation of food-related and/or technology-based quality improvement initiatives in LTC (Ducak & Keller, 2011; Anciado, Ilhamto, Keller, & Duizer, 2012; Alexis, 2003; Ontario LTC Association, 2018). Currently, the time allotment required to prepare 3DPPF in-house makes it an unrealistic option in LTC, it is therefore preferable to focus on commercially manufactured 3DPPF. In order to overcome the funding and time barriers and to promote uptake of 3DPPF by LTC homes, food manufacturers and suppliers should offer 3DPPF at an affordable cost while ensuring that the products could be prepared and served efficiently in the LTC context. Although the issues with time constrains and cost were addressed in the context of printing pureed food in-house, this perspective provides an insight on residents' and family members' interest in realistic and applicable solutions. Therefore, it is necessary to ensure that the implementation process of 3DPPF in LTC is evaluated and accepted by dietary team members and food service managers to ensure successful uptake and realistic implementation.

5.5 Limitations

This study was limited by the small number of participants which likely have impacted the potential to reach data saturation. Residents with cognitive impairments had minimal engagement in the interviews and offered only nominal responses which resulted in short interviews and a limited insight about residents' perspective on 3DPPF. Additionally, there wasn't sufficient involvement of residents receiving pureed food as many of these individuals usually have health issues and functional impairments limiting their ability and interest in participating in interviews (Keller & Duizer, 2014b). As well, the variability of food shown in the picture presentations of the different types of pureed food limited our ability to obtain a true comparison between these foods. Finally, the unavailability of 3DPPF for taste testing presented a barrier in obtaining a comprehensive assessment of residents' perception of these products.

5.6 Conclusion

This is the first known study that has explored consumers' perspectives on the potential of 3D printed food specifically for health and therapeutic purposes. The results of this study will help inform researchers, food manufacturers, and suppliers in developing 3DPPF products that meet LTC residents' and their family members' expectations. The descriptive thematic analysis identified that above all, residents and family members valued satisfaction with the food and enjoyment of the mealtime experience. They thought that taste and visual appeal of the food were the most important sensory attributes driving satisfaction with the meal quality. In offering foods that taste good and are visually appealing, 3DPPF could help overcome some of the issues associated with pureed diets. While participants were excited about the technology and were open to novel approaches to improving the dining experience for pureed food consumers, they

acknowledged potential barriers to implementation within the LTC context. Overall, the technology was acceptable, however a more comprehensive operational and sensory assessment, including taste-testing, is required to fully evaluate the potential uptake of 3DPPF by Ontario's LTC homes' residents and their family members.

Chapter 6: Part 3. Manuscript 3: Dietary Team Members' Perspectives on the Potential for 3D Printed Pureed Food in Long-Term Care Homes

Unsubmitted Manuscript

Background. Dietary team members play an important role in the production and service of pureed food in LTC. Novel interventions aimed at improving the quality of pureed food would affect their practice and procedures and therefore they should be involved in such quality initiatives. In this study, we explore dietary team members' perspectives on the potential for a novel product, namely 3DPPF, in LTC.

Methods. This was a qualitative study with an interpretive description methodology. Purposive sampling was used to recruit dietary team members (cooks, dietary aides, and dietary managers) from five participating homes. A total of 19 participants were recruited to participate in individual or group interviews (I=17). A semi structured interview guide was used to help understand team members' perspectives on the practicality, feasibility, usefulness, implications, barriers, and potential of 3DPPF in LTC. Verbatim transcription was done by the first author for all interviews. Transcripts were coded line-by-line and meaningful themes identified by the first author and confirmed by the senior author.

Results. Three over-arching themes emerged from the qualitative data. Team members described that current production and service processes are challenging for all types of pureed food. They added that if 3DPPF is to be introduced in LTC, it should fit within the LTC context by accounting for policy, procedures, and resource limitations. Finally, they zoomed in on quality by sharing requirements for 3DPPF and added that such quality improvement interventions could improve residents' nutritional health, dining experience, and quality of life.

Discussion. Team members described that variations in production techniques often lead to inconsistent and unappealing pureed food. They also spoke about service issues experienced with pre-shaped and traditional pureed food products. Participants described that 3DPPF would be a desirable alternative if it could help overcome these challenges and yield a consistent and appealing product. However, a careful environmental and contextual assessment and an effective change management strategy would be required to ensure that 3DPPF fits within the LTC context and complies with policy, procedures, and standards. Team members shared that taste, visual appeal, shape integrity, consistency and texture, variety, ingredients and additives, as well as safety would all affect acceptability of the product in LTC. They added that appropriate training and education should be provided in order to ensure that they are equipped with the skills and capacity to offer these products. Finally, the drive to offer a quality dining experience and to ensure adequacy of intake were the primary motives in improving the quality of pureed food and 3DPPF was thought to have some potential in helping to achieve these goals.

Conclusion. The implementation of 3DPPF in LTC could help resolve some of the current challenges experienced with production and service of pureed food and could improve residents' intake and their dining experience. In order to ensure that 3DPPF fits within the LTC context, a piloting phase and an effective and comprehensive training program should be done prior to implementation. Finally, the products should be produced to meet quality standards and requirements for LTC homes.

6.1 Introduction

There is increased awareness about the prevalence of malnutrition and its detrimental effects on older adults residing in LTC (Pezzana et al., 2014; Namasivayam-McDonald et al., 2018; CFHI, 2014; Keller et al., 2017a). In order to reverse and/or prevent malnutrition, regulatory bodies, public health authorities, and advocacy groups have been lobbying for quality improvement initiatives aimed at increasing residents' food intake by enhancing the quality of the food and the dining experience in LTC (Byles et al., 2009; Anderson & Um, 2017; Dietitians of Canada, 2019; Cranley et al., 2012). One area that is thought to be of particular importance is the requirement to improve the quality of pureed food (Dietitians of Canada 2019; Byles et al., 2009). This is driven by the motivation to reverse some of the negative effects of pureed diets on residents' nutritional status, health, well-being, and quality of life (Vucea et al., 2018a; Keller et al., 2018; Martino, Beaton, & Diamant, 2009). One aspect of the pureed food that has been posing many concerns is its appearance; in a study by Keller & Duizer (2014b) residents and their family members described that the traditional pureed food is visually unappealing, indistinguishable, and looks like "baby food". Similar accounts have been shared in another study with hospitalized older adults who thought that the pureed food did not look appetizing (Blaise, 2010). Strategies aimed at enhancing the visual appeal of pureed food, including food molding and piping, have been proposed to make the diet more acceptable and to increase residents' satisfaction with the food and with the mealtime experience (Dietitians of Canada 2019; Byles et al., 2009). However, such interventions have only been evaluated in controlled settings with conflicting evidence regarding effectiveness; While some studies showed that pureed food consumers preferred shaped products (Alexis, 2003; Germain, Dufresen, & Grey-Donald, 2006; Cote, Payette, & Gagnon, 2017), others identified that older adults may be inclined towards traditional scooped pureed food (Stahlamn et

al., 2000; Lepore et al., 2014). Moreover, while team members working in LTC seem to recognize the importance of enhancing the quality of pureed food (Keller & Duizer, 2014c; Watkins et al., 2017), the procurement and/or preparation of shaped products may not always be a viable option due to many operational, logistical, and policy constraints (Murphy, Holmes, & Brooks, 2017; Anciado, Ilhamto, Keller, & Duizer, 2012). This paper explores the potential of a novel and innovative food product, namely 3D printed pureed food (3DPPF), in improving the appeal of pureed food by offering food items that look like their natural shapes. The objective is to evaluate dietary team members' perspective on the feasibility and potential usefulness of this innovation in LTC including its perceived benefits, limitations, barriers, and considerations.

6.2 Methods

6.2.1 Overview

This was a qualitative descriptive study with an interpretive, inductive thematic analysis that examines perspectives of residents and family members, dietary team members, and dietitians. Five Ontario LTC homes that were part of the researchers' network were purposely sampled and invited to participate in the study. The LTC homes included in this study represented a variety of business-models (for-profit and not-for-profit). All homes confirmed use of pureed food for residents. Only the analysis based on dietary team members' perspectives is presented here.

6.2.2 Participants

Dietary team members were recruited using purposive sampling strategy from the five participating LTC homes. A total of 19 dietary team members were recruited to participate in this

study and a total of 17 in-person interviews (I=17) were conducted. One of the 17 interviews included 3 team members while the other interviews were individual.

A demographic questionnaire was completed by team members at the beginning of each interview. Table 6.0 provides detailed description of the participating team members and the types ofpureed food offered in the homes. Participants were majority female and had considerable work experience in LTC with 74% of participants having more than 5 years of experience in the dietary department in LTC. There was appropriate representation of the different roles with majority of participants (42%) being dietary aides. While dietary managers (26% of participants) did not prepare or serve the food, the majority (32%) of the other participants were involved in both the preparation and service of the food. Most homes (4 out of 5) served only in-house scooped pureed food and only one home offered manufactured pre-shaped products. That home has a mixed system with predominant use of molded food and incorporation of traditional scooped pureed food for products that aren't available in pre-shaped format.

Table 6.0 Participant Information for team members (n=19)

Demographics Information		**Participants n (%)**
# of cooks **# of dietary aides** **# of dietary managers**		6 (32%) 8 (42%) 5 (26%)
Gender	Female Male Missing Data	13 (69%) 4 (21%) 2 (10%)
Time working in LTC as cook/dietary aide/dietary manager	< 6 months 6 months – 2year > 5 years	1 (5%) 4 (21%) 14 (74%)
Work status	Full time Part time Casual	14 (74%) 4 (21%) 1 (5%)
Tasks performed	Preparing food Serving food Both Neither Missing data	3 (16%) 4 (21%) 6 (32%) 5 (26%) 1 (5%)
Types of pureed food offered in the homes		**Homes n (%)**
Types of pureed food offered in the home	Scooped pureed food, produced in-house only Manufactured pre-shaped pureed food only Mixed system (scooped & manufactured)	4 (80%) 0 (0%) 1 (20%)
Predominant type of pureed food	Produced in-house Commercially prepared	4 (80%) 1 (20%)

6.2.3 Interviews Data Collection

Interviews were semi-structured, individual, and conducted in person by one researcher. The duration of the interviews varied between 5 and 20 minutes. The interview structure included three distinct parts; the first was a discussion around team members' perspective on the pureed food and their experience with the different types of pureed food. The second part was an introduction to 3DPPF through a researcher-developed video presentation of pureed carrot medallions. Participants were encouraged to ask questions about the technology, as means of identifying

potential areas of concern. The third part was a discussion with a focus on exploring team members' perspective on the potential for 3DPPF within the LTC context. Interviews were based on a semi-structured interview guide (Table 6.1) and data collection was an iterative process whereby questioning was updated according to emerging ideas, findings, and interactions with early participants. Interviews were audio-recorded and verbatim transcription completed by two researchers, SA and VT.

Table 6.1 Interview guide for team members' interviews

Structure of the Discussion Groups	
Part 1 *Understanding team members perspective of the pureed food and their experience with the different types of pureed food.*	What is the process of preparing and/or serving pureed food here? What are some challenges you experience with serving/preparing pureed food? What are some things that are going well with the serving/preparation process of pureed food? What is your experience with commercially prepared pureed food products (including questioning on benefits, challenges, and limitations)?
Part 2 *Presenting and describing 3D printed pureed food to team members*	*Introduction to 3DPPF though video presentation and narration of production process (food used in video: pureed carrots shaped into medallions with the 3D printer). The video provided a presentation and description of: 1) the food pureeing process and environment, 2) the 3D printer and the printing process, 3) the steps of storing in a freezer and the retherming in a conventional oven, and 4) finally the presentation of 3D printed pureed food on the plate.*
Part 3 *Exploring team members' perspective on 3D printed pureed food and addressing their questions and concerns.*	What are your thoughts on this new way of making and presenting pureed food? How would 3DPPF impact residents who receive pureed food? What would be some challenges/limitations you foresee with preparing/serving this type of food in LTC? What other information would you need about this type of pureed food?

6.2.4 Data Analysis

All interviews were analyzed by one researcher (SA) and member checked by the senior author (HK) at every step of the analytical process. The coding process was informed by grounded theory which calls for the application of several levels of coding to develop a substantive theory (Thorne, 2008). In this study, only open and axial coding were used to develop themes; open coding is applied first and it consists of fracturing of the data to examine similarities and differences. This is followed by the identification of axial codes to connect and categorize the textual fragments (Thorne, 2008). An inductive analysis approach was used with the constant comparison technique applied to help uncover commonalities across team members' accounts (Thorne, 2008). All coding was done manually using Word Processor 2010.

Once coding was completed and codes were reviewed and confirmed by HK, meaningful and useful themes and sub-themes were identified by grouping codes that represented similar ideas. Thematic memos were developed based on the proposed themes, sub-themes, and potential quotes supporting each theme. These were then reviewed by HK who provided feedback and recommendations for revision. A final copy of the thematic memos was then drafted.

5.3.5 Ethics and consent to participate

Ethics approval was obtained from the University of Waterloo Research Ethics Board (ORE#31978). Participants provided informed written consent to participate in the study. Verbal reminder regarding ability to withdraw at any time was provided at the beginning of each interview. All audio recordings and transcriptions of data were stored on a password-protected secure drive belonging to the research team's lab. Participants were aware that some of the quotations would be used in the dissemination of this work and that these would be de-identified.

6.3 Results

Team members revealed many operational and quality issues associated with the pureed diet. They recognized the need to enhance the quality of pureed food in order to increase residents' satisfaction with the food and improve the mealtime experience. Three major themes emerged from the interviews. Team members described current challenges faced with the production and service of traditional and pre-shaped pureed food. They also spoke about some of the negative effects a pureed diet prescription has on residents' health, mealtime experience, and quality of life. While they recognized the potential benefits of 3DPPF on improving residents' mealtime experience and quality of life, team members identified some barriers that could impede the implementation of this novel food within the LTC context. Theydescribed that, in order for 3DPPF to be a viable option in LTC, its implementation should be based on effective change management techniques which would take into account context, resource availability, operations, procedures, policy, and legislations. Additionally, team members spoke about the importance for 3DPPF to deliver on quality in order to help overcome some of the issues associated with current types of pureed food. Further elaboration of the themes is provided in Table 6.2

Table 6.2 Summary of themes and applicable quotes for team members' interviews

Producing pureed food is challenging	
Production and service considerations for traditional pureed food	*"It's kind of interesting because I do get to go ahead and work with my own kind, you know, make my own kind of composition. But see that's the thing, it's just it's not super consistent"*P4S1(Cook) *"It's very simple, you just follow the recipe that you're given, you take the measurements of your food plus your liquid to make it a little bit more palatable."*P6S3(Dietary Aide) *"For rice or anything with starch or breading, you just don't want it to be too thick in your mouth*" P6S3(Dietary Aide) *"Some of the cooks think that they'll make whatever they can do and dump it all in the blender. It's a constant challenge to get the cooks in a mindset of understanding that they're doing this for the resident."*P3S5 (dietary Manager) *"it's much easier to just say to yourself "okay I have so many people that I have to worry about" and that not even have to worry about composition or that kind of thing"* P4S1 (Cook) *"When it comes to textures of food now that's pretty high up on, but sometimes I can see it being an issue potential for and even for myself on a busy day where that kind of attention to detail kinda falls further down"* P4S1 (Cook) *"If you puree your own you have to add stuff to it and it waters out the nutrition so the nutritional value and if you have a resident who is a picky eater or who doesn't eat or forgets how to eat now if you give them one bite {of the commercial pureed} and that's all they get they get the most nutrition in that one bite versus something that we make ourselves {the traditional pureed}. Because you have to add water to itand water has no nutritional value that way (…) You're thinning out the product in order to blend it to get it to break down properly and then you have to thicken it again, so you've actually diluted it even more"* P5S1(Cook)
Retherming and service considerations for pre-shaped products	*When I get the product I have to read the packaging…what it requires and how it needs to be defrosted and how it needs to to be served as well"* P7S2 (Cook) *"And it would be tough to just incorporate, let's say every single protein and every vegetable minus blends, how would you serve these plates of pureed food? What like every other day?"*P2S3 (Dietary Manager) *"We have the two forms the puck and the forms. Um the pucks are challenging because it, it it kind of in order to heat it up you have to do it in the steamer, that's the best way"* P5S1 (Cook) *"So it's {3DPPF}a little wet and that's probably just from the steamer* " P5S1 (Cook) *"Later on when it comes on the market, it is something we have to look at. That it keeps the shape in transport, in the freezer, by steaming, by the process of steaming and then in transport from wherever you steam it, to the plate."*P3S5 (Dietary Manager)

	"But with the formed, um there's really no negative because you pull off the syran wrap, you plop it on to the plate, you just kind of push it on the bottom and it just pops out" P5S1 (Cook) *"Okay, let's think about it this way. So, we've got 8 people currently who are on pureed texture, upstairs umm and 3 downstairs. So how, how would we heat that up? Per portion? Cz that's not gonna work. We would have to be able to heat it up in bulk and have enough room to steam table."* P2S3 (Dietary Manager) *"So umm that being held on the hot tables here, what I'm thinking of is the space that we have, we can hold 4 to 6 cups of carrot in a small container, how would that be serving 35 residents? How would it be laid out? Or could it be on top of each other."*P4S2 (Dietary Manager) *"It's {3DPPF} wonderful; I have no negatives about it except space, If I would have the space to serve it all. On top of three other textures"*P4S2 {Dietary Aide} *"And another issue is portion size. So what will be the portion size? So I get this perfect portion and by the time I reheat it and steam it, will it shrink?"*P3S4 (Dietary Manager) *"P2: But does it take no space? We have other stuff to put on the plate."* P2S4 (Dietary Aide)
Fitting 3DPPF into the LTC context	
Grounding it in the LTC food service operations	*"And I actually had to purchase that freezer there when we were actually buying commercially prepared because we don't have the space in the freezer, although it is walk-in, we don't have enough room. So that thing was full, top to bottom with cases of pureed food."*P2S3 (Dietary Manager) *"How comparable is it going to be? You're paying the cook, you're paying the grocery, you're paying the delivery, you're paying the holding service because it has to be refrigerated. So there are all these factors to take into consideration."*P4S2 (Dietary Aide) *"R: And what ultimately made you switch from the commercial to the in-house?* *P2: Well it was the corporation.* *R: And do you feel that was a good move?* *P2: Absolutely because that was much more cost effective."*P2S3 (Dietary Manager) *"We used to bring in products pre-prepared, so it kinda reminds me of that. They used to come in puck form and we have those, if it was chicken, it would be pressed into a chicken leg. If it was peas, they would actually look like a puck of peas. They were more expensiveso we've just switched to the regular pureed food."*P6S3 (Dietary Aide) *"And secondly bigger issue is the number of residents on modified texture which we have in this home, that's also a factor."*P4S4 (Dietary Manager) *"Time-wise, I don't know how it would work because there are so many (...) Well considering the number of residents we have on pureed, I don't know how this would work (...) If it was 1 or 2 residents then that would be okay."* P1S4 (Cook) *"If it has the taste, if it really tastes like a real carrot and it's easy to heat then as a cook, that would be fine"* P5S1 (Cook)

	"But yea, it would just be the actual serving of it, depends who's on, it could look {shapeless} like what we have right now" P1S4 (Cook) *"As well the training because every vegetable and meat has a different kind of texture which means a different kind of prepping"* P7S2 (Cook) *"I would like to know the process about the machine that's making them: How often is it cleaned what are the procedures with that? How are you making sure that what goes in what goes out? So for people who have allergies...We have horror stories about a meat slicer not getting cleaned and everyone getting salmonella, so we wouldn't want something like that"* P9S2 (Dietary Manager) *"I wouldn't like to serve it, prepare it, or whatever. And if something, like an outbreak happens. Just like before Christmas, for cauliflower, there was a recall. So how are you going to follow up with this? Here we know who prepared the food so we can track it."* P8S2 (Cook) *"Yes I would need more information, like what the ingredients are, just because this is very important here; we need to make sure everyone is getting the proper protein, the proper nutrients, the proper everything"* P9S2 (Dietary Manager)
Ensuring compliance with ministry and corporate standards, policies, and protocols	*"The other thing we would have to figure out how many of those we'd have to give to the residents because it has to be equivalent to the scoop sizes."* P4S4 (Dietary Aide) *"Then it goes into the blender and gets scooped, scoop number 10. It depends what it is but it is mostly on average number 10."* P5S3 (Dietary Aide) *"But we do have a standard menu. So for example if we're providing regular texture egg, we have to provide a form of product, kind of scrambled egg for the puree residents."* P1S5 (Dietary Aide) *"P3: No. Just want to add that we follow standardized recipe that have been provided to us.* *R: What are the reasons you use this method?* *P4: Just to make sure that people who receive pureed receive the same food as the minced and regular, it's just pureed."* P3&4S4 (Dietary Managers)
Applying effective change management strategies prior to implementation	*"It's 2018 right? I'm pretty familiar with 3-D printing … Yeah this is this is bananas"* P4S1 (Cook) *"It's a great product that's for sure, I like it"* P7S2 (Cook) *"So there is a lot of variables in it and I'm not saying it's can't be done. I think it's a great idea in the sense it probably would increase intake."* P2S3 (Dietary Manager) *"Yea! I can see bread; I can see you guys making bread. Anything else, I think you might struggle."* P2S3 (Dietary Manager) *"R: Okay perfect. So how do you think the residents will be impacted by that?* *P2: Well of course they are going to love that (the 3D printed)."* P2S5 (Dietary Aide)

	*"That said, there could be some people in retirement or in the community who could utilize that but I think that you definitely would have to make sure it's cost effective."*P2S3 (Dietary Manager) *"Other people, maybe in the hospital, I don't know, maybe if they have sickness and they are in the hospital maybe it would be needed there…Because here it's old people and most of them…. But nothing wrong in trying."*P2S4 (Dietary Aide)
Zooming in on quality	
Creating a quality product	*"It would still have to have the correct nutrient in it?*P9S2 (Dietary Manager) *"I don't think so, because it's too much commercial, too much processed. What about the nutrition value (opinion re 3D printed puree)"*P8S2 (Cook) *"At least with the in-house puree, you know exactly what's there, it's just plain food. You're not adding other stuff to it."*P3S3 (Dietary Aide) *"Is that thickener bad for them? They get so much thickener"* P5S1 (Cook) *"That was my big concern coming in here is what, what are the common stabilizers that you guys would be utilizing for these sorts of products"* P4S1 (Cook) *"Yes because you don't want to have too many additive in it to hold its stability. You want it to be as fresh as possible."*P6S3 (Dietary Aide) *"Another question. By the time it gets to the resident, about half an hour, will the shape hold or would it be runny?"*P5S4 (Dietary Manager) *"I think, I think it would be difficult to, because we are to offer such a variety of food right?"* P2S3 (Dietary Manager) *"It'd be nice if you could have a little bit more variety than what we have now"*P5S1 (Cook) *"It's still formed {the pre-shaped commercial pureed}, but it actually had the bumps like peas and we have maybe about 8 different vegetables and maybe 12 meats"* P5S1 (Cook) *"Well I think the idea is terrific. I think that just like you and I, if something doesn't look appealing, you just don't want to eat it. If you see, let's say at a girlfriend's house, if a food doesn't look good, you probably don't even want to try it right?"*P2S3 (Dietary Manager) *"I think it's nice to have something that looks like it's supposed to. I think for identification for the residents, they eat with their eyes first. So the residents would probably like that. Rather than being {all} green, it would be peas, in the form of peas so I think they can associate that to enjoy it* P9S2" (Dietary Manager) *"And they {the staff} were excited to be able to serve something that looked like an actual pea to a resident. It's still formed, but it actually had the bumps like peas"* P5S1 (Cook)

	"I think personally it's {in-house products} preferable because that way, people on pureed would get the flavor of the regular food. I have tasted a number of pureed items, out of curiosity and it has flavor, it's not just pasty nothingness." P5S3 (Dietary Aide) *"If they don't like the taste it goes right in the garbage."* P5S1 (Cook) *"Because it depends what seasoning, each home is different. We have to go according to what the resident like and need."* P3S4 (Dietary Manager)
Offering an enjoyable dining experience	*"We actually had this presentation a couple of times and the residents thought it was interesting. (re 3D printed pureed food presentation)"* P9S2 (Dietary Manager) *"I would say 90% of residents are already convinced {with the molded food}."* P3S5 (Dietary Manager) *"I know some residents who live in this facility, in their home they might have different meats, according to individualized as for the meats. In these cases we have to provide to each of them according to their needs."* P3S4 (Dietary Manager) *"So the two show plates that are put in front of every single residents to make a choice, although a lot of people on texture modified diet cannot speak or make their own choices. Um so we kinda go by you know admission notes on what they kinda enjoy or just knowing the resident that they may not like fish so we give them the other option."* P2S3 (Dietary Manager)
Balancing between safety, health, and quality of life	*"I've seen an increase in intake {with the pre-shaped food}, an improvement in the DR, and fewer complaints. Even the staff say that it looks much nicer. So they're happy with the step of going towards the molded one."* P3S5 (Dietary Manager) *"Here a lot of the residents, they do have impairments with their vision. It's all about getting them in here and making them feel better. If they're hungry then they're dealing with other symptoms because they're hungry. And lot of our residents, they get help, so that's how they're gonna eat, by giving them encouragement and saying "this is potatoes and this is carrots in there, it's so delicious""* P4S2 (Dietary Aide) *"It's not for me, {the good quality pureed food}, it's for the residents who have challenges to swallow and digest."* P3S5 (Dietary Manager) *"Sometime I would have to remind the cooks {to improve the quality of the pureed food during production}. For example I would say "you like Mrs. Miller, don't you? Would you want her to starve here?"* P3S5 (Dietary Manager)

6.4.1. Producing pureed food is challenging

Participants shared their experience with the production and service of traditional and pre-shaped pureed food. More specifically, issues with consistency, standardization, and nutritional value were addressed in the context of traditional pureed while concerns about efficiency, space, safety, and product quality were brought forward regarding the retherming and serving processes for pre-shaped pureed food.

6.4.1.1 Production and service considerations for traditional pureed food

Team members described that traditional pureed food is obtained by blendarizing food items from the regular menu with the addition of a liquid and a thickener. Once the desired consistency is achieved, the food is transferred into deep pans and placed in the steam tables. Finally, scoops of standard sizes are used to portion foods on the plates. The most critical and challenging step of the process was identified to be the production of consistent products: *"The only challenge is to get them to the right thickness (...) to be able to get them to the right consistency in order for the residents to be able to eat them."* [P8S2: Cook]. Although there was no specific and universal description of what constitutes a "right consistency" for pureed food, a good quality product was described as a "formed ball" or "light mousse". Food items that are too soft, watery, runny, thick, or dry were considered to be of inappropriate consistency and therefore necessitated adjustments in the amount of liquid and/or thickener: *"The challenge from the homemade ones is that if the cook isn't putting in enough starch, it gets very soft and there is no more 'a formed ball'."*[P3S5: Dietary Manager]. Team members mentioned that recipe standardization, discrepancies in practice, and the composition of the food were important factors affecting product consistency. Although the use of standardized recipes is required in LTC, these are not always perfect and

sometimes need to be reviewed and revisited to ensure that they yield quality, consistent, products: *"We've worked hard on the recipes to make sure that there isn't a lot of liquid added to it, to maintain the nutrients while getting it to the right consistency."*[P9S2: Dietary Manager]. Team members' practice also has a great influence on the consistency of pureed food; for some participants, following exact recipes was non-questionable while for others, recipes were modified as needed during the production process in order to perfect the final product. These discrepancies in practice often result in food items that are inconsistent in texture, presentation, and appeal:

> *Because it is entirely variable day by day person by person they don't really have like a super solid system for making consistently pureed offerings* [P4, S1: Cook]

Food composition was thought to influence the rheological properties of pureed food which justifies why some "hard-to-puree" foods required adjustments in the amount of thickener and/or liquid to yield a quality product; for example meat products and starchy foods often needed extra liquid as they tend to become thick, dry, or coarse when pureed while vegetables with high water content become watery during the pureeing process hence the need to add more thickener. Unfortunately, such adjustments are not straightforward and could result in inconsistent and unappealing products: *"When you puree your own it doesn't have a nice consistency on the plate"* [P4S1: Cook]. The desire to obtain a quality products may be the reason behind team members' constant *"worry about composition"* [P4S1: Cook] and the failure to obtain consistent and appealing products could explain why *"nobody likes to work with and distribute pureed food"* [P3S5: Dietary Manager].

Not only does the production of traditional pureed food require careful assessment and evaluation, but serving these foods also needs particular attention to detail. Team members are constantly

trying to enhance the presentation, visual appeal, and consistency of the pureed food products at point of service. For example, gravy sauce is added to moisten dry meat products and smaller bowls are used to separate runny food items thus preventing them from getting *"all jumbled together"*[P2S4: Dietary Aide].

These issues with consistency, visual appeal, production, and service justify team members' inclination towards commercial and pre-shaped products:

> *I think now they {residents and team members} like this one, the molded, because they put it on the plate and it looks nice. The other {traditional pureed} needs to add some water and thickener. But this one {molded pureed}, the consistency is good one so they like it better.* [P2S5: Dietary Manager].

Additionally, the concern with the nutritional value of the traditional pureed food, which tends to be *"watered down"* and *"diluted"* [P5S1: Cook], may be another reason for participants' interest in commercially prepared pureed food products.

6.4.1.2 Retherming and service considerations for pre-shaped products

The implementation of pre-shaped pureed food in LTC involves the procurement, storage, retherming, and service of the food items. Team members discussed current and potential operational issues at every step of the process. Concerns with product availability were addressed as manufacturers tend to offer a limited variety of food which drives homes to compensate by incorporating in-house production. Retherming was thought to be the most complex step of the process as it necessitated particular attention to many factors including products' packaging, retherming technique and equipment, food safety, and shape integrity. Team members revealed that the products should be packaged in such a way that promotes ease of retherming while

maintaining shape integrity. The following account describes one dietary aide's experience with the packaging used to retherm specific manufactured products; the participant demonstrates how packaging plays an important role in preserving the product's quality, he also describes the failed attempts in trying to overcome the issue of inappropriate, see poorly sealed, packaging:

> *The only problem I am experiencing right now {with commercial pre-shaped products}, the packaging easily opens. So we have to re-seal it so it doesn't come out when it's getting warmed up. But there is a time limit. If you overcook the stuff we receive, it doesn't come out of the mold properly. But since the packaging is not sufficient enough, we are wrapping a few more times; it takes longer to heat so the items do not come out shaped. (…) So it's kind of a downfall because we are paying so much for it and I am wrapping it so much more, having to overcook it because it's double wrapped. So double heated because it doesn't get as hot as fast. So we're overcooking it and it loses its shape*. [P1S5: Dietary Aide].

The equipment used for retherming was also thought to affect shape integrity. For instance, using a steamer often yields a diluted product which calls for further manipulation of the final product in hopes of restoring shape integrity:

> *You wouldn't be able to keep the consistency because once you put it in the warmer then bring it upstairs to serve it, you're not putting it on the plate where it's nice and pretty*. [P1S4: Cook].

Participants with no or little experience with the pre-shaped and commercial products raised questions about the retherming process and about food safety; they mentioned that 3DPPF *"comes with some costs regarding quality issues, like temperature, utensils and use of other equipment."*

[P3S4: Dietary Manager]. They also raised concerns about batch versus individual retherming and voiced that the process would need to be streamlined in order to fit into current operations:

> *I don't think putting that on a plate {retherm individually} would be a good idea. Because we have so many people on pureed food. When we're serving we only have a short period of time so it can't be at the microwave or the steamer every single time somebody wants it* [P1S5: Dietary Aide].

Serving the pre-shaped products was also thought to be limited by some operational barriers such as space availability at the steam table, portion size, and serving equipment. Team members thought that the layout of individual portions of pureed food may not be possible within the current space constraints in the steam tables:

> *When you've got all your food items in your steam-well, it's going to take up more room than a pan of pureed food {in bulk}, right? So that would be a challenge, the space.* [P3S3: Dietary Aide].

Participants also wondered if the dimensions of the 3D printed pureed carrots were realistic to fit on the plate and they also asked *"how do we scoop them?"* [P2S4: Dietary Aide].

6.4.2. Fitting 3DPPF into the LTC context

Team members brought forward multiple operational and systematic issues that should be taken into consideration prior to introducing 3DPPF into the LTC context. They revealed the importance of using effective and evidence-based change management techniques for implementation and spoke about the necessity of meaningful and active engagement of relevant personnel in the process.

6.4.2.1 Grounding it in the LTC food service operations

Participants expressed that in order for 3DPPF to be a viable option in LTC, it has be well- grounded within the LTC context. This meant that implementation should take into account operational considerations such as storage capacity, cost, efficiency, size of the home, training, and food safety. In reflecting about previous experiences with manufactured products, one dietary manager spoke about the limited freezer space which had resulted in the purchase of a new freezer for storage. This type of investment could present an important barrier for LTC homes as they *"have to remain within a certain budget"* [P5S4: Dietary Manager]. Concerns with cost extended to labor and other equipment needs as well as to the cost of the food products themselves. 3DPPF was thought to be potentially unaffordable as it was thought to be comparable to the costly pre- shaped pureed food that is currently available in the market:

> *Most of the kitchens are already making pureed and minced in house because the commercial is very pricy. And to create something very new now {3DPPF}, it is probably very expensive. Probably more expensive than the currently available molded food which is already, as it is, very expensive.* [P3S5: Dietary Manager].

Furthermore, preparation and service should be timely as team members projected significant concerns with regards to efficiency by emphasizing on the importance of distributing the products within specific time allotment for meal service delivery. This issue was particularly prominent for bigger homes where a larger proportion of residents received pureed food: *"So the end product on the plate must be doable in time. So for us we 120 people in the DR and we serve in 20 minutes"* [P3S5: Dietary Manager]. Meanwhile, team members who were experienced with the pre-shaped products were optimistic about efficiency and mentioned that the commercial products were *"a*

little bit easier and help save a bit of time."[P1S5: Cook]. As with any new initiative in LTC, the introduction of 3DPPF would require some *"education and work with this kind of product"* [P7S2: Cook]. Training should incorporate a theoretical and a practical component to offer education and information about the technology, nutritional value, ingredients, and food safety as these were all topics of interest for our study participants. This type of information sharing may allow for an improved uptake of this novel product since reluctance to accept 3DPPF may be a result of lack of information about the products. The following accounts demonstrate how team members and residents may reject the idea of 3DPPF due to lack of or insufficient knowledge about it:

> *You know some foods cure sicknesses or diseases but this is all commercial, I don't know what they put in there, they keep it in the fridge for how long, who knows? I don't agree with it. It's not for me, no.* [P8S2: Cook].
>
> *I think some residents would have some concern with how it's processed, just because they don't understand. In their homes, they probably had frozen vegetables which are similar."*[P9S2: Dietary Manager]

Training must be ongoing and it should incorporate a hands-on component to ensure that the preparation and service of 3DPPF are easy and consistent among all staff: *"There is ongoing training needed for the staff. The older staff is a bit more challenging."* [P3S5: Dietary Manager] because after all, team members believe that if *"it's easy to prepare then the nicer the looks, the better"* [P5S1: Cook].

6.4.2.2 Ensuring compliance with ministry and corporate standards, policies, and protocols

LTC homes are highly regulated by the MOHLTC, the Ministry of labor, corporations (where applicable), and home-specific policies. In order for 3DPPF to be an acceptable option within the

LTC context, it must comply with food-related standards as dictated by the various regulations. Team members brought forwards specific procedural issues that may impact implementation based on home and corporate philosophy and standards. They also discussed the necessity of including key personnel, such as menu analysts and dietitians, in the implementation process.

Although there were many operational issues associated with 3DPPF, team members described that a home or a corporate focus on quality may promote uptake of such intervention: *"It also depends on the company and what their focus is, if their focus is on food and enhancing the dining experience, you might be lucky."* [P2S3: Dietary Manager]. The products should therefore meet quality and menu standards for LTC homes and offer a variety of food items in standardized and convenient portions: *"we have to make sure, by the ministry standard, to give them the right portion"* [P3S4: Dietary Manager]. This would facilitate the creation of menu extensions which would ultimately simplify the preparation and service of 3DPPF:

> *So the {3D printed} carrots, we would have to make sure that 1 portion is equal to 60 ml or 2 portions of these carrots would equal 60 ml. So that would have to be on our diet extensions….But the menu analyst would have to figure out how many pucks of each {3DPPF}, would be per serving.* [P2S3: Dietary Manager].

Participants emphasized the importance of offering similar foods across the board for all diet types and stated that they *"have guidelines which should be used, from Ministry point of view. So all residents should receive the same food based on a standard menu."* [P3S4: Dietary Manager]. Specific considerations for texture and nutritional value were highlighted as team members mentioned that the food should be pureed *"to the thickness of the requirement of the home, the government standard"* [P8S2: Cook] and should also be comparable to the nutritional content of

the regular diet. Meeting such requirements may be challenged by the potential unavailability of certain foods in 3DPPF format. In the following exchange, one dietary manager describes the issue of product compatibility and menu structure:

> *P2: I think it comes down to trickling down the line. Every product would have to coincide with a recipe. So the turkey for example, if it was made out of a roasted turkey breast, we can use it for turkey breast. However can we use it for a turkey schnitzel with breading? So in relation for approving a menu, it would be tricky.*
>
> *R: Right because now you are serving them what is already on the menu.*
>
> *P2: That's right, so you already know the nutritional content. So you make something for the regular texture and then trickling down. But if you are using a different diet for the pureed than for the regular, then these are two separate menus.* [P2S3: Dietary Manager]

6.4.2.3 Applying effective change management strategies prior to implementation

Participants loved the technology of 3D printing and showed enthusiasm about it by expressing that the idea was novel, *"terrific"* [P2S3: Dietary Manager], *"wonderful"* [P4S1: Cook], *'brilliant"* [P5S1: Cook], "*amazing"* [P4S2: Dietary Aide], *"cool"* [P1S5: Dietary Aide], and *"interesting"* [P9S2: Dietary Manager]. However its workability was questionable as they described that it *"may not be well grounded in what happens operationally"* [P4S1: Cook]. Although 3DPPF was thought to be advantageous in its potential to improve the visual presentation of pureed food, there was still a lot of resistance towards these products due to the numerous, previously mentioned, operational and logistical barriers. Participants thought that this novel technology may be more beneficial for other populations such as children, hospitalized patients,

older adults residing in retirement homes, and astronaut. As for LTC residents, appreciation of 3DPPF may be limited by functional and cognitive impairments:

> *Personal feeling, I don't think residents… most of them need help, they can't feed themselves. Most of them they can't even see the food. So at least we're giving them all foods the same as the minced food it's just pureed instead. 3D, I mean we can try it but I don't think it would make a big difference for them.* [P2S4: Dietary Aide].

Nonetheless, trialing these products was welcomed by team members who recommended the use of effective change management techniques such as designing a solid plan for implementation, piloting the products in LTC, and making smaller measurable changes instead of fully switching to a 3DPPF system. Effective changes were described as being solution-driven, efficient, and affordable; some examples included the use of shaped scoops to serve pureed food and the provision of staple and "difficult to puree" foods only in 3DPPF format:

> *If this was something you were to proceed with, I would probably focus on the bread… Because that would be the easiest item to order and I could see a lot of corporations actually purchasing that because it would look a lot different* [P2S3: Dietary Manager]

As part of an effective change management plan, piloting 3DDPF would require active participation of team members who thought that they could brainstorm some ideas to help with implementation: "*But I mean that's the problem, I'm a stickler for good systems…So I could think of 3 or 4 different ways I could do this {implement 3DPPF in LTC}"* [P4S1: Cook].

6.4.3 Zooming in on quality

Offering good quality food was thought to be of significant importance to residents' health, well-being, and quality of life:

> *The folks that we have here don't only suffer from swallowing issues. It's bad enough that they are in that condition and are spending the tail end of their lives in a residence. So, not to have good food is just not right.* [P5S3: Dietary Aide].

It is therefore necessary to address current issues with the types of pureed foods provided in LTC by taking into consideration concerns around taste, nutritional value, texture and shape integrity, variety, and visual appeal. By overcoming these quality issues, 3DPPF would be a desirable alternative to current types of pureed food used in LTC.

6.4.3.1 Creating a quality product

Taste was thought to be the main driver to residents' acceptability of any type of pureed food and of the pureed diet in general:

> *When someone is new to the pureed, they need a little more coaching when they eat it because the texture is different. But after they have one or two meals with the pureed food then they realize it tastes just as good* [P4S2: Dietary Aide].

Pureed food was considered acceptable if it tasted similar to the original food from which it was derived; as such, the 3D printed pureed carrot medallions should *"taste like a real carrot"* [P5S1: Cook] in order to be satisfactory. Team members showed a preference towards the taste of the in-house pureed food due to its similarity to that of the regular food. They described that seasoning and spices are used to adjust the taste according to residents' liking thus creating more appetizing

products. As for commercial pureed food, the taste was thought to be compromised by over-processing and by the inability to adjust the taste of ready-to-use foods: *"And it {3DPPF} tastes like the actual food? I don't think so. I don't believe it. This is now all these mass produced stuff."*[P8S2: Cook].

Nutritional adequacy and transparency were thought to be of primary importance when considering 3DPPF: *"It's easier to look at something that's pre-fabricated and presume that it has what it claims {in terms of nutritional content}"* [P4S1: Cook]. Team members mentioned that the products would be particularly attractive if they were enriched with *"additional nutrition"* [P4S1: Cook] and if they could help overcome some of the nutritional issues associated with other types of pureed food:

> *Every bite {of commercial pureed food} is pack full of nutrition whereas if you puree your own, you have to add stuff to it and it waters out the nutritional value. If you have a resident who is a picky eater or who doesn't eat or forgets how to eat and you give them one bite {of the commercial product} and that's all they get; they {would} get the most nutrition in that bite versus something that we make ourselves* [P5S1: Cook]

On the other hand, over processing of the food was thought to potentially impact nutritionalvalue and residents' health negatively. For this reason as well as for their concerns about the amounts and types of additives and thickeners, team members were questioning the safety and benefits of 3DPPF:

> *You know, all these people {the residents}; they have so many health issues. Who knows what kinda chemicals are in there? Is it gonna contribute to worsening their health?* [P8S2: Cook]

Although there was a desire to minimize the amount of additives and thickeners, participants recognized the need to use thickening agents to promote shape integrity, an important quality measure for pre-shaped pureed food. Variety was also thought to be a key quality consideration for 3DPPF; some participants expressed that the lack of variety offered by other food manufacturers had resulted in the abandonment of commercial pureed food systems in their homes: *"That's one of the issues that we ran into with the pucks that we were purchasing prior, there wasn't enough of a variety"* [P2S3: Dietary Manager]. Meanwhile, others mentioned that manufactured pureed food offers sufficient variety and they added that they very seldom needed to use traditional pureed food substitutions. Variety was also addressed in the context of mixed products as there were questions around the technology's potential in supporting such foods:

> *The other issue is it's going to be a challenge for example when you have mixed veggies how is it going to be combined and how would it work?* [P4S4: Dietary Manager]

Finally, team members felt strongly about the potential of visually appealing and familiar foods in improving residents' satisfaction with the pureed diet and with the dining experience. Theystated that traditional pureed food looks *"just {like} a scoop of pureed"* [P1S5: Dietary Aide] and *"like a ball of cat food"* [P5S3: Dietary Aide]. They added that the food was unrecognizable by residents and team members alike. Participants described that pre-shaped products were more visually appealing than traditional pureed food as they were distinguishable, *"looked nice, and stayed in shape"* [P2S5: Dietary Aide]:

> *I think it's {3DPPF} a great idea because sometimes the food, it all looks the same and it's very institutional because it's with the scoos so everything is always circle formed on your plate. So it would be nice if they {the residents} were able to make the connection between*

what it looks like and what they're eating. So I think it would be great in that aspect because we've had residents before who were like "what is that? {About the traditional pureed}" [P6S3: Dietary Aide].

6.4.3.2 Offering an enjoyable dining experience

Improving the quality of pureed food was highly sought after as it was thought to be beneficial in *"returning some dignity to the residents"* [P3S4: Dietary Manager]; some team members went as far as saying that implementing pre-shaped and 3DDPPF in their homes would be a *"very humane way of going about {offering pureed food}"* [P4S1: Cook]. Participants who had implemented pre-shaped pureed foods in their homes felt that residents *"enjoyed the molded pureed food"* [P5S1: Cook] and were *"receptive to it"* [P2S5: Dietary Aide] because *"they didn't really complain about it"* [P5S2: Dietary Aide]. The sentiment towards 3DPPF was similar as participants mentioned that when the project was introduced to residents, they *"thought that it was interesting"* [P9S2: Dietary Manager].

Although team members did not share any formal evaluation of residents' feedback on thepureed food in general, they seemed to be constantly observing verbal and non-verbal reactions towards these foods to then tailor production and service accordingly; for example, desserts were thought to be appreciated because *"usually, that's when you can see smiles on their {the residents'} faces"* [P4S2: Dietary Aide]. The following account demonstrates how team members gather residents' feedback on the food/mealtime experience and adjust practice to increase residents' satisfaction and improve the mealtime experience:

> *Some of the residents, they don't like food touching each other, it's a preference to what they would have grown up with and are used to, they don't forget that. So that's why we put some of the things that are runny in a smaller bowl.* [P4S2: Dietary Aide]

Promoting enjoyable dining is prioritized beyond the home level as it is considered an important quality measure at the corporate level. On dietary manager described her home's corporate philosophy around enjoyable dining as follows:

> *One of the main focuses of the corporation is pleasurable dining and they {corporate personnel} created a platform for every home to use. Food is definitely huge. So our menus changed a lot; There is much more variety in relation to cultural foods, in relation to just better quality recipes. So that is something we can control as a corporation, the quality of the food. So we can be one step ahead of everybody else.* [P2S3: Dietary Manager].

These quality improvement efforts demonstrate that there are opportunities and a strong motive to enhance the quality of the dining experience for pureed food consumers; 3DPPF could be a desirable option to achieve this goal because it seems to be *"more appetizing for residents who are forced to eat pureed food"* [P1S5: Cook].

6.4.3.3 Balancing between safety, health, and quality of life

Finding balance between nutrition, safety, and choice was particularly challenging for team members who were willing to go the extra mile to improve residents' experience with the pureed food. The inability to achieve that balance often resulted in moral discomfort for participants as they felt uneasy about allowing choices that may put residents at immediate risk. As such, participants felt badly when residents refused to eat the pureed food but were very hesitant to offer them other types of food textures before consulting with a swallowing expert:

> *We've just had someone come back from hospital and she wouldn't eat, she didn't eat for 3 days because she was cognitively aware and she looked at the food and said "no, no" but we couldn't upgrade until SLP had come in.* [P2S3: Dietary Manager]

In order to improve residents' intake while promotingsafety, team members offered interventions that aimed at making pureed food more acceptable, appetizing, and enjoyable. They suggested that providing encouragement and support at meals and serving more visually appealing food could increase residents' satisfaction with the food and consequently result in an improvement in intake. One dietary manager described that his motivation to switch to pre-shaped pureed food system was to increase residents' food intake as it was evident that pureed food consumers had the poorest intake and were therefore at high risk of malnutrition:

> *I noticed that when residents receive pureed, they are mostly the ones who aren't eating well and have the highest weight loss on average and I was looking into ways to give them more enjoyable food.* [P3S5: Dietary Manager].

This type of intervention was thought to be very effective as residents became curious and interested in trying the pureed food. In fact, team members would hear them say *"I would like to try this"* [P3S5: Dietary Manager]. This represents a remarkable change in attitude towards the pureed food which is traditionally unappealing and is described as being *"too soft, too mushy…like baby pureed"* [P3S5: Dietary Manager]. Similar to molded pureed food, 3DPPF was thought to have a great potential in improving residents' intake while promoting safety and enjoyment ofthe mealtime experience; team members believed that such products could help stimulate residents' appetite and may allow them to experience the joy of eating instead of just eating as a means of fuelling their bodies:

W*e tried explaining {that the pureed food is similar to the regular} but some residents were like "I ain't eatin' that!" But I think it {3DPPF} would be amazing, it {3DPPF} would probably do wonders for their diets and would make them want to eat instead of just doing it {eating} because they have to.* [P6S3: Dietary Aide].

6.4 Discussion

This is one of the very few studies (Ilhamto et al., 2014; Keller & Duizer 2014c; Garcia, Chambers, Russell, & Katt, 2018; Murphy, Holmes, & Brooks 2017; Anciado, Ilhamto, Keller, & Duizer, 2012; Blaise, 2010) evaluating dietary team members' perspective on pureed food and/or their opinion about the prospect of a novel intervention aimed at improving the quality of pureed food in LTC. This study demonstrates that the implementation of 3DPPF in LTC may result in improvement in multiple mealtime domains, namely meal quality, mealtime experience, and food intake, as described in the mealtime conceptual framework by Keller et al. (2014a). The impact of such improvements could decrease the risk of malnutrition and improve quality of life (Vucea, Keller, & Ducak, 2014). However, several home and government level factors as well as food-related factors must be taken into consideration to promote successful implementation of these products. As such, the challenges experienced in the production and service of pureed food should be addressed in order to yield more visually appealing, presentable, and consistent products. Similar to findings from previous work (Ilhamto et al., 2014; Blaise, 2010; Abbey, 2015; Murphy, Holmes, & Brooks, 2017), dietary team members described that the production and service of pureed food are very challenging and have significant impact on the quality of pureed food products. For example, while there was recognition of the importance of recipe standardization, team members admitted not always following these standards due to the perceived need for adjustment in liquid and/or thickening agent to yield a quality product. Similar disinclinations to

using standardized recipes were demonstrated by participants in a qualitative study by Ilhamto, Anciado, Keller, & Duizer, (2014) who identified that food service workers did not trust the instructions/ingredients in recipes and opted to experiment by adjusting measurements and production techniques. Unfortunately, such deviations from the standard do not usually have the desired effects and instead, tend to yield unappealing and inconsistent pureed food (Abbey, 2015) which could justify team members' frustration with the making of pureed food as described by our study participants. Additionally, there is no evidence suggesting that any changes in standards of preparation improves the consistency of "difficult to puree" food, instead these types of food are thought to best be offered in a commercially prepared format (Anciado, Ilhamto, Keller, & Duizer, 2012) or substituted with nutritionally equivalent, easy to puree, alternatives (Ilhamto et al., 2014). The issues with the production of pureed food may be overcome with the use of commercial products, including 3DPPF, as these would not require any preparation and may improve consistency in texture and presentation (Anciado, Ilhamto, Keller, & Duizer, 2012). However, prior to implementing such products in LTC, a careful contextual evaluation should be undertaken with particular emphasis on logistics, resources, equipment, and training needs. Without such evaluation and streamlining, implementation may prove unsuccessful. For example, in a large multi-component interventional study aimed at improving the quality of nutrition care in nine nursing homes in Australia (Byles et al., 2009), the authors identified that implementation offood molds required careful assessment of operations in order to fit the intervention within the food service system; as such, appropriate equipment, sufficient labor, a comprehensive training, and a trial phase were all required to ensure effective uptake. Whenever either of these prerequisites was unavailable, implementation of the molded food system either failed or was delayed until such time the required resources became available. Consistent with our study, Anciado, Ilhamto, Keller,

& Duizer, (2012) identified that limited freezer capacity and the high cost of commercially prepared pureed food posed a hindrance on the procurement of these food items. While the issue of freezer capacity is complex and requires detailed evaluation of the purchasing, ordering, and storage processes in LTC, cost concerns could be overcome by ensuring affordability of 3DPPF. Interestingly, accounts from our study participants and findings from previous work (Anciado, Ilhamto, Keller, & Duizer, 2012; Vucea, 2017b) demonstrate that dietary managers may be willing to spend more than the raw food allowance of 9.00$ per diem (Government of Ontario, 2017) on commercial pureed products given that these provide better quality food and a more dignifying mealtime experience for pureed food consumers. While dietary team members may be flexible with costing, the views about policy requirements were rather rigid and non-negotiable. In their work about resident-centered menus in LTC, Ducak & Keller (2011) offered a detailed description of policy barriers similar to those identified by our study participants. For example, portion sizes should be standardized according to the requirements of Canada's Food Guide, 2007 (Government of Canada, 2019) and all menus should have a wide variety of food items without any meal repetition for five days (Ducak & Keller, 2011). Our study participants also described that the ministry requires that pureed menus match the regular menu very closely. They added that even the smallest alteration in the original menu, see roast turkey instead of turkey schnitzel, may be problematic. Similar accounts were shared in another qualitative study with food service providers who described that they avoided using any types of commercial pureed products to ensure compliance with ministry standards and to prevent citations by ministry auditors during inspections (Ilhamto et al., 2014). However, the authors of the study argued that there seems to be misinterpretations of the ministry recommendations since the LTC Act (MOHLTC, 2007) allows substitutions that are comparable to the planned menu. In our study, the worry about using roast

turkey instead of turkey schnitzel is likely one such misinterpretation of policy requirements. This demonstrates that although it may not be necessary for 3DPPF to offer all types of foods in all formats, a wide variety of food should be provided in order to match the regular menu as closely as possible. Alternatively, a mixed system of in-house and commercial products could be implemented in LTC to improve weight and nutritional status (Keller et al, 2012b) with a focus on offering staple foods and "hard to puree" food in 3DPPF format. More specifically, high-water containing vegetables, meat products, and bread, which were described as being particularly unappealing when pureed in-house, may be more desirable if offered in a consistent, commercially prepared, 3DPPF format. This was reiterated by Anciado, Ilhamto, Keller, & Duizer (2012) who described that dietary managers prioritized purchasing commercial pureed food for items that are difficult to puree such as watery vegetables, some glutinous starches, and meat products. While our study participants and others (Keller & Duizer, 2014c; Anciado, Ilhamto, Keller, & Duizer, 2012) described that commercial products could help improve consistency, texture, and/or visual appeal of the pureed food, there were prominent concerns around taste alterations in these products; team members described that over-processing and out-of-site production could negatively impact taste recognition and authenticity thus yielding less desirable products. This was further demonstrated by Stahlman et al. (2000) and Lepore et al. (2014) who argued that consumers' preference of traditional pureed food may be justified by the taste alterations caused by differences in production techniques/ingredients and gel formation in the molded pureed products. While the making of 3DPPF is further complicated by the printing process which requires the product to be flowable enough to pass through the nozzle and firm enough to hold its structure during printing (Yang, Zhang, & Bhandari, 2017), some studies showed that it is possible to create a product that has a desirable, non-gelatinous, texture by using the appropriate amount

and type of hydrocolloids such as xanthan gum, agar, and gelatin (Lipton et al., 2010; Huang, 2018). Enhancing the taste of the product by improving its rheological properties could increase the uptake of 3DPPF however the requirement to customize the taste of pureed food and to match it to that of the regular food may continue to pose a hindrance on the acceptability of 3DPPF in LTC (Anciado, Ilhamto, Keller, & Duizer, 2012). These concerns around taste suggest that recipes for the making of 3DPPF should be carefully designed in order to avoid gel formation and ultimately preserve the taste of the original food. Additionally, products should be taste-tested at the home-level prior to implementation in order to determine acceptability (Ettinger, Keller, Duizer, 2014).

The issues described demonstrate that although the technology of 3D food printing spiked interest among participants and was rather perceived positively, the implementation of 3DPPF in LTC is very complex and requires effective and evidence-informed change management and quality improvement strategies. Consistent with guidance from Health Quality Ontario (2012), participants described that, in order for 3DPPF to be a viable option in LTC, it should be an effective, safe, equitable, efficient, appropriately resourced, and integrated solution to the nutritional and quality problems associated with pureed food. If it is considered to be one such solution, HQO advises the formation of a quality team to carry the planning, implementation, studying and evaluation of the initiative (Health Quality Ontario, 2012). Accounts from our study participants reveal that such teams should include dietary team members as well as other key personnel such as dietitians and menu analysts to formulate a solid and clear plan for implementation. Although not mentioned in this study, the inclusion of nursing staff in the quality teams would also be required as their attitude and practice have an important impact on the quality of pureed food and on the mealtime experience (Keller & Duizer, 2014c; Wu et al., 2018). This

kind of interdisciplinary collaboration would offer an opportunity for training, information sharing, and empowerment; as such, workability and value-based considerations would be explored and addressed to promote successful and effective uptake by all parties involved in the project (Low et al., 2015). LTC homes and quality teams should expect that quality initiative, such as 3DPPF, in LTC would require significant efforts and collaborations, new routines, changes in material and equipment, as well as inscribed documents to enable implementation and promote sustainability (Stoopendaal & Bal, 2013). Quality team should therefore be equipped with champions who have a strong motive and drive for quality improvement (Health Quality Ontario, 2012). Finally, ongoing and sustainable training and education would be required because "Implementing new routines requires a great deal of 'translational work'. New knowledge has to be translated over and over to make it understandable and workable" (Latour, 1987).

6.5 Limitations

Our study was limited by a small number of participants experienced with commerciallyprepared and pre-shaped pureed food products. For the most part, participants shared potential and hypothetical considerations instead of real life experiences with commercial products. A comprehensive perspective could not be inferred from the data due to the unavailability of the product for testing and piloting as these were important considerations in shaping team members' attitude and perspectives on 3DPPF. Finally, it was not possible to gain a global understanding on the applicability of 3DPPF in LTC without the soliciting other social actors such as nursing staff, corporate personnel, and senior management.

6.6 Conclusion

This is the first known study to evaluate the perspective of food service providers regarding the workability of 3D printed food in a specific healthcare sector. The result from this study will help suppliers, food manufacturers, and researchers in developing 3DPPF products that meet team members' expectations. Additionally, the results would help researchers and LTC homes' managers in streamlining a process for effective implementation of 3DPPF in LTC. The descriptive thematic analysis identified that team members recognized the need to improve the quality of pureed food and sought solutions that would target current production and service challenges experienced with pureed food. They added that the products should deliver on quality and help overcome some of the current sensory and quality issues associated with different types of pureed food. While team members were excited about 3D food printing and recognized its potential benefits to residents' health, well-being, and quality of life, they thought that a comprehensive environmental and contextual assessment should be undertaken to address operational, logistical, and policy barriers. Finally, an effective and evidence-informed change management strategy should be used to promote uptake and successful implementation of 3DPPF in LTC.

Chapter 7: Discussion

Stakeholders' involvement in research has been shown to be of particular value to researchers and those who benefit from research alike as it increases the relevance of findings to the particular population of interest (National Institute for Health Research, 2009). In fact, evidence-based implementation frameworks, such as the knowledge-to-action (K2A) cycle, recommend stakeholders' involvement at all stages of knowledge synthesis and implementation (Straus, Tetroe, & Graham, 2013). This project aimed at exploring the potential of 3DPPF in LTC based on stakeholders' perspectives. Chapters 4-6 of this thesis offered a detailed analysis about the perspectives of RDs, residents and family members, and dietary team members on 3DPPF and its potential in the LTC context. The following discusses the implications of this work.

7.1 Appreciating the relative advantage of 3DPPF

The diffusion and uptake of a novel innovation is thought to be strongly influenced by its relative advantage as perceived by consumers (Rontelap et al., 2007). In this study, participants identified current issues associated with all types of pureed food and ways in which 3DPPF could help overcome these issues. As such, RDs described that improving the appeal of pureed food through 3D printing could help overcome the ongoing refusal of a pureed diet prescription. Team members identified production and service issues associated with traditional and pre-shaped pureed food and described that 3DPPF could potentially help overcome these challenges. Finally, residents and family members described that 3DPPF could improve residents' satisfaction with pureed food and offer a more pleasurable dining experience to pureed food consumers. Although this novel technology was perceived rather positively, concerns around complexity and compatibility with current practice were highlighted by participants. Consistent with Rogers' (2003) theory on the

diffusion of innovation, our study participants identified that it would be required to trial 3DPPF and evaluate its acceptability, feasibility, and effectiveness prior to implementing it in their homes.

7.2 Exploring the potential for implementation based on theoreticalframeworks

Although the objective of this study was not to generate generalizable findings, it was essential to ensure that our findings were transferable to similar contexts. A theoretical framework is used as a guide to discuss these overall results as a means of exploring meditating pathways and barriers to implementing 3DPPF in LTC (McEvoy et al., 2014). The Theoretical Domains Framework (TDF) was selected as it describes cognitive, affective, social, and environmental factors affecting implementation (Atkins et al., 2017). Due to the large number of TDF domains, an integrated framework incorporating the TDF and the Capability, Opportunity, Motivation (COM-B) behavioral change model by Michie, Atkins, & West (2014) was used to also guide this discussion. Figure 7.0 demonstrates the linkage between TDF and COM-B by showing TDF domains groupings based on their source of behavior.

Figure 7.0 Integrated TDF and COM-B Frameworks

Adapted from Atkins et al. (2017)

The COM-B model represents the cornerstone of the framework shown in figure 7.0 with the essential drivers for behavior change being Capability, Opportunity, and Motivation. The COM-B model suggests that in order for any behavior to occur, the individuals performing it should possess the physical and psychological capabilities required, the environment should also offer opportunities to enable individuals in performing the behavior, and there must be enough motivation to drive change and incentivize individuals in performing the behavior (Michie, Atkins, & West, 2014). In the following discussion, we present the capabilities, opportunities, and motivations required to implement 3DPPF in LTC based on participants' perspectives and by elaborating on categorical domains within the TDF.

7.2.1. Capability: Equipping stakeholders with the skills and knowledge

Behavior change and the implementation of new interventions require that those involved in the process possess the physical and psychological capabilities needed for effective implementation (Michie, Atkins, & West, 2014). In our study, participants described that considerations about knowledge, skills and physical capability, memory and decision process, and behavioral regulation should all be taken into account prior to implementing 3DPPF in LTC.

Participants had very minimal knowledge about and no exposure to 3DPPF; they requested comprehensive information about the products in order to assist with informed decision making regarding uptake. As such, nutritional and rheological information, food safety, and product composition and ingredients were major areas of interest across groups. The RDs and residents/family groups questioned dietary team members' capabilities of preparing and serving 3DPPF as this product has not been tested in an actual LTC setting. Team members reiterated this concern by stating that they would require comprehensive training to ensure effective

implementation and uptake. They added that since 3DPPF would require changes in processes in food service operations, training should be ongoing to promote retention and sustainability. Participants thought that the uptake of 3DPPF would be regulated by its effect on residents' health, well-being, and quality of life. Therefore, there should be systems to monitor effectiveness in order to assist LTC homes in determining if such initiative is worthwhile.

7.2.2 Opportunity: Social dynamics and environmental influences

The communal dining room set-up in LTC was thought to influence residents' satisfaction with and acceptability of pureed food. In fact, participants described that residents tend to compare their pureed meals to the food offered to their table mates and to the regular show plates. This kind of comparison often leads to poor satisfaction with the pureed food and a desire for foods that look like their natural shape. As a result, participants described that the introduction of more visually appealing products, such as 3DPPF could help overcome the issue of social comparison. While implementation of 3DPPF in LTC was thought to be socially desirable, effective change management approaches were considered necessary to promote the effectiveness of this intervention and they should capitalize on the social dynamics of the home. For instance, the multidisciplinary nature of LTC would allow for the collaboration of various social actors and quality improvement teams should include all relevant disciplines and individuals. Inclusion of residents and family members would further help to tailor the intervention according to residents' liking through taste-testing and acceptability studies. Additionally, by involving dietary team members, nursing staff, RDs, menu analysts, corporate personnel, and management in quality teams, the project would be piloted and streamlined according to contextual, professional, and procedural considerations. This type of interdisciplinary collaboration was thought to be required for the exploration of attitudes towards pureed diets in general and 3DPPF in particular. Byactively

including front-line personnel, implementation design and planning would be streamlined according to the environmental influences of current practices, limitations, barriers, and opportunities. Quality improvement teams would also offer a foundation for information sharing and knowledge exchange about the characteristics, implementation, and uptake of 3DPPF.

Many environmental and contextual factors were thought to affect the implementation of 3DPPF in LTC. For example, uptake was thought to be maximized for smaller homes that do not have a high number of pureed food consumers. As well, the current availability of similar products, such as commercially prepared pureed food molds or pucks, in the home seemed to be conducive to higher acceptability of 3DPPF. On the other hand, many environmental barriers were thought to hinder workability and uptake of 3DPPF; these were mainly dictated by resource availability and policy/procedural requirements. As such, the issue of time constraints was highlighted as a potential barrier by all participant groups. RDs and dietary team members offered comprehensive and detailed descriptions of other important contextual considerations including cost, equipment requirement, and policies and standards for menu structure and food quality. It was identified that in order for 3DPPF to be a desirable alternative in LTC, homes should be furnished with the appropriate equipment for storage, retherming, and service. These would promote environmental opportunity for this new technology. Additionally, food items should have a nutrient profile and serving sizes that are comparable to those of the regular diet. 3DPPF should also offer a variety of foods to meet the MOHLTC's requirements of matching the regular menu. Finally, rheological properties should meet IDDSI standards in order for the products to be a desirable option for LTC homes.

7.2.3 Motivation and attitude

Motivation is described as the "processes in the brain that energize and direct behavior" (West, 2013) and it is influenced by individuals' plans, responses, impulses, motives, and evaluation (Michie, Atkins, & West, 2014). The eight domains relating to reflective and automatic motivation in the TDF were reflected in our qualitative data as follows:

7.2.3.1 Social/professional role and identify

Dietary team members and RDs demonstrated that their caregiver and professional roles influenced their interest in ensuring nutritional adequacy and safety while maximizing residents' quality of life; offering an enjoyable dining experience and honoring residents' choice were thought to be important pillars for promoting resident satisfaction with the food. Unfortunately, the types of pureed food currently available to LTC homes was thought to be limiting in its ability to balance between health, safety, and quality of life and 3DPPF was seen as a desirable alternative. This perspective was also projected by family members and non-pureed food consumers who occupied a role of advocacy for residents' health, safety, and well-being.

7.2.3.2 Beliefs about capabilities and optimism

Team members who had no experience with pre-shaped pureed food products demonstrated great reluctance towards 3DPPF and stated that they would require extensive training and a piloting phase in order to increase their confidence in producing and serving these products in LTC. On the other hand, those who had previous experience with commercially prepared pureed food displayed a higher level of confidence in the workability of 3DPPF in LTC and believed that these products could even help save time for production and service. Our study shows that it would be necessary to improve team members' confidence in offering 3DPPF by providing extensive training and by piloting the product in LTC. This type of exposure would equip participants with

the experiential learning required to formulate an informed opinion about the potential of 3DPPF in LTC. Additionally, further testing, piloting, and research would help build an evidence base about product quality and implementation which may affect participants' optimism about the use of 3DPPF in LTC.

7.2.3.3 Beliefs about consequences

Participants described positive and negative potential consequences associated with the implementation of 3DPPF in LTC. They thought that 3DPPF could help improve residents' satisfaction with their meals and increase the acceptability of a pureed diet prescription. On the other hand, participants described that 3DPPF may increase food cost, threaten food safety, pose an encumbrance on current procedures and practices, and/or result in non-compliance with ministry and corporate standards for food quality and menu structure. A careful evaluation was thought to be required in order to prevent these undesirable consequences and to ensure that the products meet LTC homes' needs and requirements.

7.2.3.4 Intention

Participants described that enjoyable dining is a core component of quality care and efforts are constantly made to improve residents' dining experience. While there is no documentation or reports about the implementation of 3DPPF in a real institutional context, other interventions are used in LTC to improve the quality and acceptability of pureed food. These include: using food molds and pucks; piping pureed food; offering foods that are naturally pureed; and liberalizing pureed diets. Since LTC homes recognize the issues associated with pureed food and have the intention, motive, and drive to overcome these issues, 3DPPF may find its place in LTC, especially if the product is designed in such a way that is compatible with current practices and procedures.

7.2.3.5 Goals/Reinforcement/Emotions

Participants' ultimate goal for 3DPPF was to offer a more enjoyable dining experience for pureed food consumers and to improve their intake and meal satisfaction. In order to achieve this outcome, participants described that the products should deliver on quality in terms of nutritional value, visual appeal, taste, consistency, variety, and safety. Additionally, 3DPPF should fit within the LTC context while taking into account operational, logistical, resource, and policy considerations. If 3DPPF meets these requirements and helps achieve the desired goals, it would reinforce the value of 3DPPF and participants' concerns about barriers and limitations could be reduced resulting in becoming incentivized to use the technology in LTC.

7.3 Designing interventions for implementation

Interventions should be designed based on behavioral issues associated with uptake as described and by targeting barriers to implementation (Michie, Atkins, West, 2014). In this study, five types of intervention functions were identified to be necessary for effective implementation and uptake of 3DPPF in LTC. More specifically, education and training would be required to improve capabilities, knowledge, and confidence with this novel product, environmental restructuring would help overcome the issues of contextual barriers, and incentivisation and enablement would increase participants' motivation for implementation (Michie, Atkins, West, 2014).

7.3.1 Education and training

Staff education and training is required for the implementation of best practice nutrition care in LTC (Dietitians of Canada, 2019). As such, team members are provided training for meal/snacks delivery, food production and service, food safety, as well as for new initiatives such as IDDSI (Dietitians of Canada, 2019). Consistently, in our study, participants described that further

knowledge and training would be required to promote implementation of 3DPPF in LTC; a well-designed program could improve knowledge and attitude towards 3DPPF while supporting behavior change (Dietitians of Canada, 2019). In order to ensure that the training program is effective, team members should be involved and collaborate in planning and delivery. Additionally, resident-focused goals and measures should be incorporated to provide a rationale for the need for such an alternative in LTC (Moyle, Hsu, Lieff, & Vernooij-Dassen, 2010). Training material should describe operational philosophy and standards and training sessions should be scheduled at a time that is convenient for team members to attend (Moyle et al., 2010). Furthermore, management and organizational support would be required to maximize clarity of procedural specifications and to ensure that team members are provided with sufficient resources and time to fulfill training needs (Stolee et al., 2005). Without such comprehensive planning and collaboration, training and education may prove unsuccessful, thus hindering uptake of 3DPPF in LTC.

7.3.2 Environmental restructuring

Environmental and contextual factors are thought to influence residents' food intake and their mealtime experience (Murphy, Holmes, & Brooks, 2017; Edwards & Gustafsson, 2008; Keller et al., 2014a; Iuglio, 2017; Keller, Chaudhury, Pfisterer, & Slaughter, 2017b). Management control systems, including budget, policies, and procedures, play an important role in shaping the mealtime experience by governing service delivery, product quality, and social interactions (Edwards & Gustafsson, 2008). In our study, participants described that policies and procedures tend to be inflexible and that 3DPPF should be produced and implemented in such a way as to meet LTC homes' standards for food service operations and food quality. On the other hand, there were some opportunities for environmental restructuring in relation to equipment and menu structure; team

members were not opposed to procuring the equipment needed to produce and serve pureed food as long as the cost of such equipment is within the LTC homes' budgetary constraints. They also described that menu sheets could be adapted by including extensions to reflect 3DPPF products and their portion sizes.

7.3.3 Enablement and Incentivisation

Participants described that the biggest incentive to offering 3DPPF would be to improve residents' intake, mealtime experience, and acceptability of a pureed diet prescription. Providing a product that has a competitive advantage was thought to be incentivizing for LTC homes. For example, fortification and compliance with IDDSI standards were considered effective approaches to marketing 3DPPF to LTC homes. The motivation to procure 3DPPF would also be increased through the use of a collaborative approach in planning and implementation as this would empower stakeholders involved in the process and would also enable them to tailor interventions according to their specific needs (HQO, 2013).

7.4 Key recommendations to promote uptake of 3DPPF in LTC

Based on the analysis and key findings of this thesis, the following recommendations are offered to promote uptake of this technology in residential care foodservice:

- Form multidisciplinary quality teams for planning, implementation, and evaluation the introduction of 3DPPF; include: residents, family members, dietary and nursing team members, RDs, menu analysts, corporate personnel, and management.
- Evaluate contextual and home-specific barriers such as cost, time constraints, equipment, policy, and procedures.

- Pilot 3DPPF in LTC and evaluate its acceptability, feasibility, and effectiveness prior to implementation.
- Offer comprehensive, ongoing, and collaborative training to equip team members withthe skills required for preparation and service.
- Offer comprehensive information about the product to all groups of stakeholders by being transparent about nutritional and rheological properties, food safety, product composition, ingredients, and types and amounts of thickener used.
- Design and implement monitoring systems to assess effectiveness and impact on residents' health, well-being, and quality of life.
- Conduct taste-testing with family and residents to then tailor taste according to their preference.
- Furnish the homes with the appropriate equipment for storage, retherming, and service of 3DPPF.
- Adapt and revise menu sheet extensions to reflect 3DPPF products and their portion sizes.
- Ensure that 3DPPF meets the LTC homes' standards and requirements in terms of nutrient profile, texture requirements, serving size, and variety.
- Design a product that is compatible with current practices, procedures and equipment.
- Ensure that the product delivers on sensory qualities, including visual appeal, taste, texture, and consistency.
- Provide 3DPPF products that have a competitive advantage. Example: protein fortification and use of IDDSI terminology.
- Conduct further testing, piloting, and research to build an evidence base about product quality and implementation.

7.5 Next steps

The results of this project will be presented to the participating LTC homes and discussed with team members, families, residents, RDs, and management as appropriate. The findings will also be disseminated on a larger scale in research conferences and translated to pertinent communities of practice, such as the Dietitians of Canada Gerontology Network. Chapters 4-6 will be submitted for publication in scholarly journals to help inform the research community about emerging findings pertaining to 3D printing, 3DPPF, and pureed food in LTC. The findings from the study could also be of interest to industry partners who offer specialized nutrition for elderly consumers. The research team could therefore use this work for future collaborations with food suppliers and for further development in the area of 3DPPF.

Chapter 8: Conclusion

This project aimed at exploring the perspectives of three groups of participants regarding 3DPPF in LTC. Participants were comprised of RDs, residents and family members, and dietary team members. All groups identified issues associated with current types of pureed food and described that sensory attributes such as taste, visual appeal, and consistency are important factors affecting the quality of these products. 3DPPF was perceived positively in its potential to improve the consistency and the visual presentation of pureed food by offering food that is distinguishable and visually appealing. However, many concerns about product quality and implementation were brought forward by all groups. Participants described that the products should meet LTC homes 'policy standards and procedures while delivering on nutritional value, appearance, consistency, texture, taste, variety, and safety. Participants demonstrated a high level of motivation to implement 3DPPF in LTC however they described that environmental and contextual barriers as well as the lack of experience with 3DPPF would influence the effectiveness of such interventions in LTC. They described that a comprehensive training, a piloting phase, and further testing of quality and acceptability would be required in order to improve the capabilities and opportunities required for implementation and to promote uptake of 3DPPF in LTC. Although not ready for implementation, a variety of recommendations are provided to promote uptake of 3DPFF in LTC in the future.

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Appendix

Appendix A: information letters and consent/assent forms

UNIVERSITY OF WATERLOO

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RESDIENT/FAMILY INFORMATION LETTER AND CONSENT FORM FOR INTERVIEW

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

This letter is to inform you about a study we are conducting to understand how residents and care partners would perceive 3D printed pureed food in their home. Professor Heather Keller from the University of Waterloo, and Sarah Awwad, University of Waterloo masters student, will be conducting this study. You are invited to participate in an interview to provide your input on this novel approach to re-shaping pureed food.

Why are we doing this study?

There is some evidence to suggest that residents who receive a pureed diet may benefit from an improvement in the sensory appeal of their food. A novel food production technology, namely 3D pureed food printing, is being explored by researchers and industry partners to improve the quality of pureed food provided to residents in LTC homes. This study aims to explore how this food would be perceived by residents, family members, and care partners to ensure that the final products would be feasible, realistic, and beneficial to residents of long-term carehomes.

What will happen during this study?

You will be asked to participate in an interview whereby the research student (Sarah Awwad) will ask you questions to understand what you think of re-shaping pureed food using 3D printing technology. This technology will be further explained to you through photos and videos during the interview. Your participation is completely voluntary. This interview should take 30 to 45 minutes. You also have the option to have a family member or any person of your choice to participate in the interview with you. With your permission, the interview will be audio recorded to make sure

that none of your valuable input is missed. Additionally, with your permission, quotations from the interview may be used in the final report, without the use of any identifiers.

Will there be any risks to your family member during this study?

It is unlikely that there will be any harm, risk, or discomfort from participation in this study. All information we gather will be kept confidential and management, staff, and other residents will not know any of your responses to the questions. A summary of all responses will be provided in our report. Steps to protect your privacy are provided below. You do not need to answer questions that you do not want to answer or that make you feel uncomfortable. You can withdraw from or stop taking part in this study at any point in time and any data you have provided will be destroyed.

What are the benefits of doing this study?

Your input will be of great value to tailor 3D printed pureed food according to your perceived needs. The research may not benefit you directly, but it will help us understand how to improve the quality of pureed food provided in LTC homes. The results can help direct researchers and industry partners in developing 3D printed pureed food products that would be acceptable, beneficial, and feasible for residents in LTC homes.

Will my family member receive any remuneration for participating in this study?

No remuneration will be provided.

How will my family member's information be kept private?

We will not use your name or any information that would allow you to be identified; we will use a unique code instead of your name in the interview transcript. We will ensure that all answers you provide are confidential and secure. Only the research team will have access to your interview recording and transcript. Home management will receive a general report for the study They will not know who participated or how you responded to the interview questions, unless you choose to tell them or disclose your responses.
All the hard copy information associated with the interview will be kept in a locked cabinet and all electronic files kept on a computer will be protected by a password in a research office at the University of Waterloo. Results reported will be in a summary format with very careful attention to exclude any information that could identify you or the long-term care home where you live. Once the study is complete, all hard copy data collected will be destroyed by Professor Heather Keller after 5 years. Electronic data will be retained for a minimum of 7 years in a secure location within Professor Keller's research lab at the University of Waterloo.

What if I change my mind about having my family member involved in this study?

Your participation in this study is completely voluntary. It is your choice to be part of the study or not and in no way will participation affect the care you receive at [FACILITY NAME]. If you decide

to not be part of the study, you can ask the research student to end the interview for whatever reason and at any point in time, even after you provide written consent or part-way through the interview or even after completing the interview. If you do not want to answer some of the questions, you do not have to, but you can still be in the study. If you decides to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise.

How can I find out about the results from this study?

You may obtain information about the final results of this study by contacting Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca . A brief summary of this study's results will be confidentially emailed or mailed to you. At the end of this study we will also provide a summary of results if requested during presentations for management, staff, Residents' Council and Family Council meetings.

How do I get more information about this study and my involvement in it?

If you or your family member have any questions or need more information about this study please contact Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

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Student Investigator:
Sarah Awwad, Master's Candidate
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- I have read and understood the information and consent form.
- I have had sufficient time to consider the information provided and to ask for advice.
- I have had the opportunity to ask questions and have had satisfactory responses.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the research objectives.
- I understand that my participation in this study is voluntary and that I am completely free to refuse to participate or to withdraw from this study at any time.
- I understand that I am not waiving any of my or my legal rights as a result of providing consent for participation.
- I understand that I have the option of allowing my interview to be audio-recorded to ensure an accurate recording of my responses.
- I understand that excerpts from the interview may be included in presentation or publications to come from this research, with the understanding that the quotations will be de-identified.
- I understand that there is no guarantee that this study will provide any benefits to me.
- I understand that if a situation occurs that may be/is harmful to other residents, staff, and/or to myself (i.e., verbal, emotional, psychological, physical, or sexual abuse), this interaction will be reported to the director of care.
- I have read this form and I freely consent to participate in this study.
- I agree to have my interview audio recorded. ☐ YES ☐ NO
- I agree to the use of de-identified quotations in any presentation or publication that comes of this research. ☐ YES ☐ NO
- I would like to have:

  ☐ An individual Interview ☐ An interview in presence of another person

Specify Name: _____

Contact Information:

_____

Signatures

Printed Name of Resident	Signature	Date

_____

Signature Mark Date

Verbal consent obtained: ☐ YES ☐ NO

Reason for verbal consent or signature mark:

_____

_____

_____

Dr. Heather Keller

Printed Name of Principal Investigator	Signature	Date

Alternatively, you may provide consent for your family member's participation via email by indicating to either the Primary Investigator (Prof. Heather Keller, hkeller@uwaterloo.ca) or Student Investigator (Sarah Awwad, s2awwad@uwaterloo.ca) that you have read this form and freely consent to having your family member and/or yourself participate in the interview. You can also provide a verbal consent acknowledging that you have read and understand the information provided in this letter and consent form if the interview is conducted over the phone.

Protocol for Attaining Resident Assent to Participate in an Interview

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

In the event a resident doesn't have the capacity to provide informed consent, the following information letter will be read with/to the resident and the assent protocol will be followed.

1. Why are you here?

I would like to talk to you to find out what you think about a new way of making pureed food using 3D printer to help make it look better.

2. Why are they doing this study?

We would like to find out your thoughts on this new method of making pureed food. This will help us give recommendations to meet your needs.

3. What will happen to you?

We will interview you in the presence of <POA/SDM's name> (if available). It will take about 30 minutes and we will look at pictures and videos to help with our talk.

4. Will there be any risks?

No

5. Will your information be kept a secret?

Yes they will be saved in a locked box and not shared with anyone except the researcher.

6. Will the study help you?

It will help us find ways to improve pureed food to meet your expectations.

7. Do you have to be in the study?

You do not have to be in the study. No one will be upset if you do not want to do this. If you do not want to be in the study, tell me or your family member. Even if you say yes, you can change your mind later. It is up to you.

8. What if you have any questions?

You can ask questions at any time, now or later. You can talk to your family or Professor Keller who is the primary researcher for this study. You can ask your family member to help you contact them:

Primary Investigator:
Heather Keller, RD, PhD, FDC
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DIETARY TEAM MEMBERS CONSENT FORM FOR INTERVIEW

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

This letter is to inform you about a study we are conducting to understand how residents and care partners would perceive 3D printed pureed food in their home. Professor Heather Keller from the University of Waterloo, and Sarah Awwad, University of Waterloo masters student, will be conducting this study. You are invited to participate in an interview to provide your input on this novel approach to re-shaping pureed food.

Why are we doing this study?

There is some evidence to suggest that residents who receive a pureed diet may benefit from an improvement in the sensory appeal of their food. A novel food production technology, namely 3D pureed food printing, is being explored by researchers and industry partners to improve the quality of pureed food provided to residents in LTC homes. This study aims to explore how this food would be perceived by residents, family members, and care partners to ensure that the final products would be feasible, realistic, and beneficial to residents of long-term care homes.

What will happen during this study?

You will be asked to participate in an interview whereby the research student (Sarah Awwad) will ask you questions to understand what you think of re-shaping pureed food using 3D printing technology. This technology will be further explained to you through videos during the interview. Your participation is completely voluntary. This interview should take 30 to 45 minutes. With your permission, the interview will be audio recorded to make sure that none of your valuable input is missed. Additionally, with your permission, quotations from the interview may be used in the final report, without the use of any identifiers.

Will there be any risks to your family member during this study?

It is unlikely that there will be any harm, risk, or discomfort from participation in this study. All information we gather will be kept confidential and management, other staff, and residents will not know any of your responses to the questions. A summary of all responses will be provided in our report. Steps to protect your priva cy are provided below. You do not need to answer questions that you do not want to answer or that make you feel uncomfortable. You can withdraw from or stop taking part in this study at any point in time and any data they have provided will be destroyed.

What are the benefits of doing this study?

Your input will be of great value to tailor 3D printed pureed food according to your input. The research may not benefit you directly, but it will help us understand how to improve the quality of pureed food provided in LTC homes. The results can help direct researchers and industry partners in developing 3D printed pureed food products that would be acceptable, beneficial, and feasible for residents in LTC homes.

Will I receive any remuneration for participating in this study?

You will be compensated $15 for your time for participating in this study.

How will my information be kept private?

We will not use your name or any information that would allow you to be identified; we will use a unique code instead of your name on in the interview transcript. We will ensure that all answers you provide are confidential and secure. Only the research team will have access to your interview recording and transcript. Home management will receive a general report for the study They will not know who participated or how you responded to the interview questions, unless you choose to tell them or disclose your responses.
All the hard copy information associated with the interview will be kept in a locked cabinet and all electronic files kept on a computer will be protected by a password in a research office at the University of Waterloo. Results reported will be in a summary format with very careful attention to exclude any information that could identify you or the long-term care home where you live. Once the study is complete, all hard copy data collected will be destroyed by Professor Heather Keller after 5 years. Electronic data will be retained for a minimum of 7 years in a secure location within Professor Keller's research lab at the University ofWaterloo.

What if I change my mind about having my family member involved in this study?

Your participation in this study is completely voluntary. It is your choice to be part of the study or not and in no way will participation affect your job at [FACILITY NAME]. If you decide to not be part of the study, you can ask the research student to end the interview for whatever reason and at any point in time, even after you provide written consent or part-way through the interview or even after completing the interview. If you do not want to answer some of the questions, you do not have to, but you can still be in the study. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you have provided will be destroyed unless you indicate otherwise.

How can I find out about the results from this study?

You may obtain information about the final results of this study by contacting Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca . A brief summary of this study's results will be confidentially emailed or mailed to you. At the end of this study we will also provide a summary of results if requested during presentations for management, staff, Residents' Council and Family Council meetings.

How do I get more information about this study and my involvement in it?

If you or your family member have any questions or need more information about this, study please contact Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

Primary Investigator:
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Student Investigator:
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- I have read and understood the information and consent form.
- I have had sufficient time to consider the information provided and to ask foradvice.
- I have had the opportunity to ask questions and have had satisfactory responses to myquestions.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the research objectives.
- I understand that my participation in this study is voluntary and that I am completely free to refuse to participate or to withdraw from this study at any time.
- I understand that I am not waiving any of my or my legal rights as a result of providing consent for participation.
- I understand that I have the option of allowing my interview to be audio-recorded to ensure an accurate recording of my responses.
- I understand that excerpts from the interview may be included in presentation or publications to come from this research, with the understanding that the quotations will be de-identified.
- I understand that there is no guarantee that this study will provide any benefits to me.
- I understand that if a situation occurs that may be/is harmful to other residents, staff, and/or to myself (i.e., verbal, emotional, psychological, physical, or sexual abuse), this interaction will be reported to the director of care.
- I have read this form and I freely consent to participate in this study.
- I agree to have my interviewaudio recorded. ☐ YES ☒ NO
- I agree to the use of de-identified quotations in any presentation or publication that comes ofthis research. ☐ YES ☒ NO

Signatures

Printed Name of Dietary Aide	Signature	Date

Dr. Heather Keller

Printed Name of Principal Investigator	Signature	Date

Alternatively, you may provide consent for your family member's participation via email by indicating to either the Primary Investigator (Prof. Heather Keller, hkeller@uwaterloo.ca) or Student Investigator (Sarah Awwad, s2awwad@uwaterloo.ca) that you have read this form and freely consent to having your family member and/or yourself participate in the interview. You can also provide a verbal consent acknowledging that you have read and understand the information provided in this letter and consent form if the interview is conducted over the phone.

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REGISTERED DIETITIANS INFORMATION LETTER AND CONSENT TO PARTICIPATE IN DISCUSSION GROUP

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

This letter is to inform you about a study we are conducting to understand how residents and care partners would perceive 3D printed pureed food as an alternative to traditional pureed food. Professor Heather Keller from the University of Waterloo, and Sarah Awwad, University of Waterloo masters student, will be conducting this study. You are invited to participate in a focus group over teleconference and with a group pf 4-5 other RDs. Your input regarding this novel approach to re-shaping pureed food is of great value to advancement in research and development of 3D printed pureed food.

Why are we doing this study?

There is some evidence to suggest that residents who receive a pureed diet may benefit from an improvement in the sensory appeal of their food. A novel food production technology, namely 3D pureed food printing, is being explored by researchers and industry partners to improve the quality of pureed food provided to residents in LTC homes. This study aims to explore how this food would be perceived by residents, family members, and care partners to ensure that the final products would be feasible, realistic, and beneficial to older adults who resides in the LTC home.

What will happen during this study?

You will first be asked to complete a demographics questionnaire, before the day of the focus group. This questionnaire could be completed online via a web link which will be shared with you or by phone (5 -minutes phone call with research student, Sarah Awwad). On the day of the discussion group, the research student, Sarah Awwad, will contact you and 4-5 other interested RDs to connect over a teleconference. The discussion will be scheduled on a day and time that are convenient to participants and will take approximately an hour in order to give everyone an opportunity to provide their valuable input. With your permission, the focus group will be audio recorded to make sure that none of your valuable input is missed. Additionally, with your permission, quotations from the focus group may be used in the final report, without the use of any identifiers. You will be required to have access to internet connection during the teleconference in order to discuss a video pertaining to 3D pureed food printing.

Will there be any risks to you in this study?

It is unlikely that there will be any harm, risk, or discomfort from participation in this study. All information we gather will be kept confidential and only individuals participating in the focus group as well as the researchers associated with the study will know your input on the various topics discussed. A summary of all the data obtained in this study will be published in a final report. Steps to protect your privacy are provided below. You do not need to answer or provide your input in for questions/topics if you do not want to or feel uncomfortable discussing any of the topics. Additionally, you are at liberty to withdraw from the discussion at any time; you

may leave the discussion group. Should you decide to withdraw from or stop taking part in this study at any point in time any data (input, opinion) you have provided will be destroyed.

What are the benefits of doing this study?

Your input will be of great value to tailor 3D printed pureed food according to residents' needs. The research may not benefit you directly, but it will help us understand how to improve the quality of pureed food provided in LTC homes. The results can help direct researchers and industry partners in developing 3D printed pureed food products that would be acceptable, beneficial, and feasible for residents in LTC homes.

Will I receive any remuneration for participating in this study?

No remuneration will be provided.

How will my information be kept private?

The focus group discussions will be audio recorded, with your permission and will then be transcribed without any identifiers then stored in a lock box. A summary report will be produced with all the data gathered in this study without identification of particular data obtained from any individual/group. Homes participating in this study as well as the DC Gerontology Network will receive a summary based on variety of perspectives collected in this study. They will not know who participated or how you or your group answered to the various topics of discussion, unless you or any individual participating in the group discussion choose to tell them or disclose the responses shared during the focus group discussion. The research student will re-iterate the importance of keeping the information discussed confidential however we cannot guarantee that other RDs participating in the discussion group will not share this information with others.

All the hard copy information and transcripts form the group discussion will be kept in a locked cabinet and all electronic files kept on a computer will be protected by a password in a research office at the University of Waterloo. Results reported will be in a summary format with very careful attention to exclude any information that could identify yourself, the individuals participating in the group discussions. Once the study is complete, all hard copy data collected will be destroyed by Professor Heather Keller after 5 years. Electronic data will be retained for a minimum of 7 years in a secure location within Professor Keller's research lab at the University of Waterloo.

Please note in case you opt to complete the demographics questionnaire online, we cannot guarantee privacy of information. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). University of Waterloo researchers will not collect or use internet protocol (IP) addresses or other information which could link my participation to my computer or electronic device without first informing me.

What if I change my mind about having my family member involved in this study?

Your participation in this study is completely voluntary. It is your choice to be part of the study. If you decide to not be part of the study, you can stop providing input or leave the discussion group. In order to provide you with complete comfort in discussing your withdrawal, please contact the research student upon completion of the focus group discussion and let her know that you would like withdraw participation. Withdrawal can be done at any point in time for whatever reason, even after you provide written consent. If you decide to withdraw, there will be no consequences to you. In cases of withdrawal, any data you provided will be destroyed unless you indicate otherwise.

How can I find out about the results from this study?

You may obtain information about the final results of this study by contacting Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca . A brief summary of this study's results will be confidentially emailed or mailed to you. At the end of this study we will also provide a summary of results if requested during presentations for management, staff, Residents' Council and Family Council meetings.

How do I get more information about this study and my involvement in it?

If you have any questions or need more information about this study, please contact Professor Keller at 519-888-4567 ext. 31761 or by email at hkeller@uwaterloo.ca

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

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- I have read and understood the information and consent form.
- I have had sufficient time to consider the information provided and to ask for advice if necessary.
- I have had the opportunity to ask questions and have had satisfactory responses tomy questions.
- I understand that all of the information collected will be kept confidential and that the results will only be used for the research objectives.
- I understand that my participation in this study is voluntary and that I amcompletely free to refuse to have them participate or to withdraw from this study at any time.
- I understand that I am not waiving my legal rights as a result of providingverbal/email consent for participation.
- I understand that I have the option of being audio-recorded to ensureanaccurate recording of my responses.
- I understand that excerpts from the focus group may be included in presentation or publications to come from this research, with the understanding that the quotations will be de-identified.
- I understand that there is no guarantee that this study will provide any benefits tome.
- I understand that if a situation occurs that may be/is harmful to me or anyone in the group discussion (i.e., verbal, emotional, psychological, physical, or sexual abuse), this interaction will be reported to the director ofcare.
- In case I opt to complete the demographics questionnaire online, I acknowledge that I understand that when information is transmitted over the internet privacy cannot be guaranteed and that there is always a risk my responses may be intercepted byathird party (e.g., government agencies, hackers). I also understand that the University of Waterloo researchers will not collect or use internet protocol (IP) addresses or other information which could link my participation to my computer or electronic device without first informing me.

- I have read this form and I freely consent to having my family member participate inthis study.
- I agree to have my interview audio recorded. ☐YES ☐NO
- I agree to the use of de-identified quotations in any presentation or publication that comes of this research. ☐YES ☐NO

Signatures

Printed Name of Registered Dietitian	Signature	Date

Dr. Heather Keller

Printed Name of Principal Investigator	Signature	Date

Alternatively, you may provide consent for your family member's participation via email by indicating to either the Primary Investigator (Prof. Heather Keller, hkeller@uwaterloo.ca) or Student Investigator (Sarah Awwad, s2awwad@uwaterloo.ca) that you have read this form and freely consent to having your family member and/or yourself participate in the interview. You can also provide a verbal consent acknowledging that you have read and understand the information provided in this letter and consent form

APPENDIX B: Demographics questionnaires

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DEMOGRAPHICS QUESTIONNAIRE FOR RESIDENTS/FAMILY MEMBERS

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

Resident/Family Member I.D…….

Question 1: Age:

Question 2: Gender: a) Male b) Female c) Other, Specify……..

Question 3: I am a

a) Resident
b) Family member of a resident/Friend of a resident. ***Specify relationship to resident***…….

Question 4: I/the resident I am related to have/has been living in this home for:

a) Less than 6 months
b) 6 months to 1 year
c) 1 to 3 years
d) 3 to 5 years
e) More than 5 years

Question 5: I/the resident I am related to receive(s) a:

a) Puree diet
b) Minced diet
c) Regular diet
d) Other, Specify: ……

Question 6: I/the resident I am related to have/has been receiving the diet order above for:

a) Less than 6 months
b) 6 months to 1 year
c) 1 to 3 years
d) More than 3 years

Question 6: The research team would like to request participating residents' Cognitive Performance Score (CPS) from home management. Are you agreeable to sharing this information with the team?

a) Yes
b) No

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DEMOGRAPHICS/OPERATIONS QUESTIONNAIRE FOR DIETARY MANAGERS

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

Dietary Manager I.D…….

Question 1: Gender: a) Male b) Female c) Other, Specify:……..

Question 2: Length of time working at this home

a) Less than 6 months
b) 6 months to 2 years
c) 2 years to 5 years
d) More than 5 years

Question 3: Length of time working as a dietary manager in LTC

a) Less than 6 months
b) 6 months to 2 years
c) 2 years to 5 years
d) More than 5 years

Question 4: Work status at this home:

a) Full time
b) Part time
c) Casual

Question 5: Which of the following are used in your LTC home? (circle all that apply)

a) Scooped pureed food, produced in house
b) Molded or piped pureed food, produced in house
c) Commercially prepared pureed food

Question 6: Which is the predominant production method for pureed food in your LTC home?

a) In-house production
b) Commercially prepared

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DEMOGRAPHICS/PROCEDURES QUESTIONNAIRE FOR DIETARY AIDES

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

Dietary Aide I.D…….

Question 1: Gender: a) Male b) Female c) Other, Specify:……..

Question 2: Length of time working at this home

e) Less than 6 months
f) 6 months to 2 years
g) 2 years to 5 years
h) More than 5 years

Question 3: Length of time working as a dietary aide/cook in LTC

e) Less than 6 months
f) 6 months to 2 years
g) 2 years to 5 years
h) More than 5 years

Question 4: Work status at this home:

a) Full time
b) Part time
c) Casual

Question 5: Which of the following apply to your daily tasks

a) Preparing food
b) Serving food
c) Both

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DEMOGRAPHICS QUESTIONNAIRE FOR DIETITIANS

AN EXPLORATION OF RESIDENTS' AND CARE PARTNERS' PERSPECTIVE ON 3D PRINTED PUREED FOOD

Dietitian I.D……. Discussion Group #:……

Question 1: Gender: a) Male b) Female c) Other, Specify:……..

Question 2: Length of time working as a dietitian in LTC

i) Less than 6 months
j) 6 months to 1 year
k) 1 years to 3 years
l) 3 years to 5 years
m) More than 5 years

Question 3: Work status in LTC:

d) Full time
e) Part time
f) Casual

Question 4: Who performs swallowing assessments in your LTC home

a) RD
b) SLP
c) Both but predominantly RD
d) Both but predominantly SLP

Question 4: Who provides recommendations for changes in diet texture for residents

a) RD
b) SLP
c) Both but predominantly RD
d) Both but predominantly SLP

Question 5: My level of knowledge about 3D pureed food printing is

a) Minimal
b) Moderate
c) Advanced

Appendix C: Interview Schedules

Family/resident interview

Introductory script: Hello! Thank you for accepting to participate in this study. As you read in the information letter, we are exploring a strategy to make the pureed food more appealing, using a 3D food printing technology. Before we start, I would like to remind you that all your answers will remain confidential and you may decline to answer any question at any time. You can withdraw your participation, please let me know if you wish to do so and we will proceed accordingly. Do you have any questions for me before we start? Are you still okay to have this interview audio recorded?

Before we start talking about the specific strategy we are studying, I would like to gain some understanding on how pureed food is perceived in general and I would like to ask you a few questions pertaining to your perspective on the pureed food provided in this home. Is this okay?

Question 1: What type of food texture do you receive? *Show puree, mined, and regular.

If receives puree:

Question 2: How would you describe your (your loved one's) food?

Question 3: What do you like about it?

Question 4: What do you like less? How about the texture? The look? The taste?

If does not receive puree:

Question 2: Do you know anyone in this home who receives pureed food?

Question 3: What do they tell you about it?

Question 4: What do you think of it? What do they tell you about it?

Show pictures (Picture A, B, C)

Question 5: What foods you see on these pictures?

Question 6: Which one of these looks the most appetizing to you?

Question 7: Which one looks less appetizing?

Question 8: If you had a choice between all three which one would you pick?

Question 9: Do you have any ideas on how to improve pureed food?

Okay now let's watch a video and see how it's actually made

Questions 11: What do you think of it now?

Question 12: What are some things that may worry you about food if it's made this way?

Question 13: What else would you want to know about this type of puree food?

Appendix K: Nutrition Manager Interview

Introductory script: Hello! Thank you for accepting to participate in this study. As you read in the information letter, we are exploring a strategy to make the pureed food more appealing for the residents, using a 3D food printing technology. Before we start, I would like to remind you that all your answers will remain confidential and you may decline to answer any question at any time. You can withdraw your participation, please let me know if you wish to do so and we will proceed accordingly. Do you have any questions for me before we start? Are you still okay to have this interview audio recorded?

Before we start talking about the specific strategy we are studying, I would like to gain some understanding on how pureed food is perceived in general and I would like to ask you a few questions pertaining to the preparation of pureed food in this home. Is this okay?

Question 1: How is pureed food produced here?

Question 2: What are some reasons you use (method indicated in question 1)?

Question 3: What are some challenges you face with the pureed products prepared that way?

Question 4: Have you ever tried an alternative to this type of pureed food?

Question 5: How was that experience?

Question 6: What were some challenges?

Question 7: If there was a new pureed food product on the market that is made in such a way to look like the regular form of the food (Show picture C). What would be your thoughts on supplying it to the residents?

Question 8: What would motivate you to purchase it?

Question 9: What would demotivate you?

Let's watch a video to understand better how this food is made

Question 10: What are your thoughts on the product now?

Question 11: Could you think of ways it would help you overcome some of the challenges you are currently experiencing with the pureed food?

Question 12: Could you think of limitations to using this product?

Question 13: Do you feel you have enough information on these products to decide if you would supply them to the residents?

Question 13: What other information would you need?

Appendix L: Dietary Aides/Cooks Interview

Introductory script: Hello! Thank you for accepting to participate in this study. As you read in the information letter, we are exploring a strategy to make the pureed food more appealing for the residents, using a 3D food printing technology. Before we start, I would like to remind you that all your answers will remain confidential and you may decline to answer any question at any time. You can withdraw your participation, please let me know if you wish to do so and we will proceed accordingly. Do you have any questions for me before we start? Are you still okay to have this interview audio recorded?

Before we start talking about the specific strategy we are studying, I would like to gain some understanding on how pureed food is perceived in general and I would like to ask you a few questions pertaining to the service of pureed food in this home. Is this okay?

Question 1: Could you please tell me about the process of serving pureed food in this home?

Question 2: What are some challenges you experience during food service with pureed food?

Question 3: What are some things that are going very well in the service with respect to pureed food?

Question 4: How about products that are commercially prepared (e.g. just need to be reheated before serving)? How are these served?

(If doesn't have any); ask to imagine having some special frozen products

Question 5: How does serving commercially prepared products compare to serving in-house prepared meals?

Question 6: Could you speak to some challenges you would see in serving them?

Question 7: What are some aspects you enjoy about serving these foods?

Imagine there was a new commercial pureed product that is made through a machine that makes it look like its real form I will show you a video that describes how it works

Question 9: If your manager brings this food in; how would you feel about serving it?

Question 10: In your perspective, how would it impact the residents who receive pureed food?

Question 11: What would be some challenges in serving it?

Question 12: What would be some limitations in having this food here?

Question 13: What do you think of this type of 3D pureed food?

Question 14: What other information would you like to know about this type of food?

Appendix P: RD Discussion Group

Introductory script: Hello! Thank you for accepting to participate in this study. As you read in the information letter, we are exploring a strategy to make the pureed food more appealing for the residents, using a 3D food printing technology. Before we start, I would like to remind you that all your answers will remain confidential and you may decline to answer any question at any time. You can also withdraw your participation, please let me know if you wish to do so and we will proceed accordingly. Do you have any questions for me before we start? Are you still okay to have this interview audio recorded?

Before we start talking about the specific strategy we are studying, I would like to gain some understanding on how pureed food is perceived in general and I would like to ask you a few questions pertaining to prescribing pureed food in this home. Is this okay?

Questions 1: Let's discuss some common reasons you would order pureed food for residents.

Questions 2: What are some negative health implications you see with a pureed diet?

Question 3: Can you remember a time you recommended a pureed diet and resident (or their family) refused your recommendation? Can someone please share an experience?

Probe: What did you think at the time? How did you feel? How would others feel? Think? Do?

To group: What are some thoughts you have on RD1's experience? How would you have felt? What would have you done?

We are researching a new technology that produces pureed food that looks like its original form through 3D printing. Let's watch a video to understand it better (PERFORMANCE).

Question 4: What are your thoughts on this new way of making and presenting pureed food?

Question 5: How would the situation (described by RD1) unfolded if you ordered this type of pureed food instead of the traditional puree?

Question 6: What do you think are requirements of this food to decrease the negative health implications associated with a pureed diet Probe: Use their ideas

Question 7: What would be some challenges you foresee with this type of pureed food?

Question 8: Do you feel that you have enough information about 3D printed pureed food to make a decision about recommending it for residents in the home? Why? Why not?

Question 9: What other information do you need to make an informed decision of whether it's appropriate to recommend 3D printed pureed food for the residents?