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## Food waste in hospitals: review

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**Abstract:** Uneaten food, whether by patients or unserved, is considered food waste. Plate waste is the remaining, uneaten food after being served to patients in the hospital. The uneaten food has a cascading environmental impact on increasing the amount of food grown or raised, energy in transport of food to hospitals, and impact of methane and carbon dioxide from landfilling the uneaten food. Food waste has been measured either by weight or visual estimation. About 500 hospitals worldwide have had food waste studies and about half are in Europe. This study is the first to quantify the limited data on different strategies for improving food waste results. There were 92 studies that documented improvement of food waste, with the single biggest change being tailoring the food choice to the individual patient's desire for food. Unserved food waste was not considered in this review.

**Keywords:** hospitals; food waste; plate waste; food system improvement.

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**Biographical notes:** Fadhel Alshqaqeeq is a PhD student in Industrial Engineering at Wichita State University. He received his Master of Science in Industrial Engineering at St. Mary's University, San Antonio, TX in 2012. He is currently working on his research for his dissertation which titled in 'Life Cycle and Energy Analysis of Products and Hospital Systems'. This research uses the critical analysis techniques of life cycle and energy analysis to better understand aspects of sustainability improvement of healthcare products and services, with an emphasis on hospitals. These areas include food systems, imaging, and product selection. The food and product topics are new areas in the WSU effort at a hospital-wide understanding of energy and waste improvement, while the imaging is a new extension of earlier work in this area.

Janet M. Twomey is the Associate Dean for Graduate Studies, Research, and Faculty Development for the College of Engineering and a Professor of Industrial and Manufacturing Engineering at Wichita State University. She served three years at the National Science Foundation (NSF) as a Program Officer, and has success in a research program on healthcare energy improvement, wind energy, and operations research. She was active in launching, shaping, and managing the new Manufacturing Enterprise Systems program in the NSF Engineering Directorate. This included managing budgets of \$7–\$10 million per year. Her graduate students, with whom she has worked closely, come from diverse origins – Iran, Saudi Arabia, Thailand, Mexico, Columbia and Nigeria.

Michael R. Overcash has developed an in-depth national research program in two distinctive areas, life cycle inventory research and sustainability research. Environmental Clarity has one of the largest chemical life cycle databases. He received his PhD from the University of Minnesota in Chemical Engineering. He has served as the Sam Bloomfield Chair in Sustainable Engineered Systems at Wichita State University.

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## 1 Introduction

Food waste can occur anywhere in the world, and food waste may result during each of these steps in the food process: transportation, storage, preparation, cooking, and consumption. Therefore focusing on food waste is important for hospitals, in order for them to save money and improve sustainability goals. For example, the annual cost for edible plate waste has been estimated at 5.625 million Saudi riyals (\$1.5 million) for 18 Ministry of Health general hospitals in Saudi Arabia for regular meals (Al-shoshan, 1992). Most food waste in a hospital is that which is thrown away, while that which is recycled or composted is a small portion. Preparing food that ends up as waste is considered mismanagement of our natural resources. One review by Williams and Walton in 2011 covered published articles from 1963 up to March 2011. In this study, we covered a larger range of years of published articles (1945 up to September 2015) and did the first quantitative analysis of the percentage food waste improvement where that was documented in the published articles. The objectives of this literature review are:

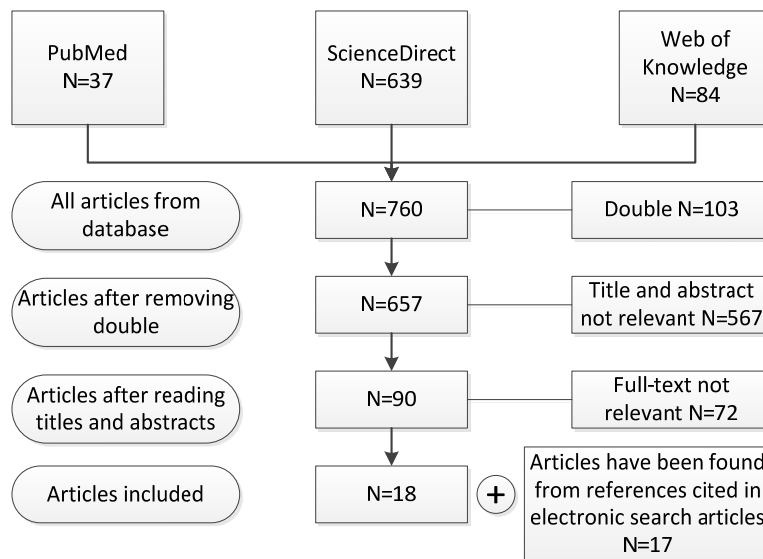
- 1 quantify and compare the percentage of food waste in hospitals
- 2 analyse the time trend of hospital food reduction studies and the global distribution of these hospitals

- 3 provide the first analysis of solutions to reduce hospital food waste based on the percent improvement achieved.

## 2 Methods

We focused our research efforts on publications that provided information about food waste associated with only hospitals. We identified related journals from electronic reference databases using combinations of key words and titles from 1945 to September 2015. The key words were ‘food waste’ and ‘plate waste’ and a secondary classification to limit the output since there were many articles on school, cafeteria, and restaurant and so on. So, the review was limited to hospitals and journals only in the English language. The following search engines were used to extract information: PubMed, Science Direct, and Web of Science (formerly Web of Knowledge). The total number of relevant titles and abstracts resulting from searches was 37 from PubMed, 639 from Science Direct, and 84 from Web of Science, for a total of 760 from all search engines. From that number, about 103 articles, which occurred in more than one database, were identified and removed with the help of endnote. A flowchart showing the search engines used in the initial pooling of the literature is summarised in Figure 1.

**Figure 1** Flowchart of selected studies indicating hospital food waste



After excluding the duplicated articles, it was determined that 567 articles had titles and abstracts not relevant to the main study, so these were excluded. Of the remaining 90 articles, 72 full texts were excluded because the discussion was about calorie waste, solid waste, waste treatment of uneaten food, supply chain management, hazardous waste in the hospitals, and other waste like chemicals, which were not included in this study. In the 18 articles an additional 17 articles were identified in the literature review of those 18 papers and these were then included to make a total of 35 papers.

**Table 1** Literature summaries of food waste

<i>Facility/hospitals</i>	<i>Weight percent of food waste from patient trays</i>	<i>Explanation</i>	<i>References</i>
1 university hospital in USA	22, 19, 13	Measured, different diets selective	Hageman (1945)
152 hospitals in UK	10 ± 0.4	Measured	Platt et al. (1963)
1 Kansas teaching hospital in USA	21.3	Measured	Frakes et al. (1986)
Royal Victoria Hospital in Canada	38.3 ± 48.9	Visual estimation	Dubois (1990)
1 hospital in Netherlands	42.7	Measured	Deutekom et al. (1991)
18 hospitals in Saudi Arabia	30	Measured	Al-shoshan (1992)
3 hospitals in Taiwan	21.51, 16.61, 6.36	Measured	Li and Jenq (1993)
1 Missouri hospital in USA	45	Measured	Holdt et al. (1993)
11 UK hospitals	9.9, 16.2, 15.5	Measured, breakfast, lunch, dinner	Hong and Kirk (1995)
Queen's Medical Center in UK	31, 34, 35, 42	Measured, 4 wards	Stephen et al. (1997)
4 hospitals in UK	23.1, 39.66, 42.35	Measured, breakfast, midday, evening	Edwards and Nash (1997)
Tickhill Road Hospital in UK	49.0–11.8	Measured (average plated and bulk)	Kelly (1999)
4 hospitals in UK	25.3, 27.8	Measured (plated and bulk)	Edwards and Nash (1999)
1 university hospital in UK	35	Measured	Barton et al. (2000a)
1 university rehabilitation ward in UK	32	Measured	Barton et al. (2000b)
1 general hospital in UK	33.5–14.5	Measured (plated vs. bulk)	Wilson et al. (2000)
1 hospital in Brazil	36–61	Measured	Mattoso and Schalh (2001)
7 community hospitals in UK	18	5-point visual estimation	Hamilton et al. (2002)
1 general hospital in UK	11.6 ± 3.0, 5.9 ± 1.9	Measured (plated and bulk)	Hartwell and Edwards (2003)

**Table 1** Literature summaries of food waste (continued)

<i>Facility/hospitals</i>	<i>Weight percent of food waste from patient trays</i>	<i>Explanation</i>	<i>References</i>
2 military hospitals in USA	42.3–45.5	Measured	Dilly and Shanklin (2003)
1 general hospital in UK	65 ± 3.8, 17 ± 5.9	Measured (plated and bulk)	Marson et al. (2003)
4 hospitals in Sivas, Turkey	17	Measured	Altin et al. (2003)
1 North Texas acute care hospital in USA	42	Average of 6 categories of estimated waste – baseline	Connors and Rozell (2004)
1 North Texas acute care hospital in USA	32	Average of 6 categories of estimated waste – food changes	Connors and Rozell (2004)
Hvidovre University Hospital, Denmark	28–48	Measured	Freil et al. (2006)
1 university hospital in Brazil	22	Measured	Nonino-Borges et al. (2006)
1 Indiana hospital in USA	40	Plate assessment	Kandiah et al. (2006)
1 university hospital in Switzerland	22–30	Not stated	Iff et al. (2008)
1 general hospital in Korea	23.2	Measured	Sohn and Yeom (2008)
1 hospital in the Netherlands	38	Measured	van Bokhorst et al. (2009)
256 hospitals in 25 European countries	18	4-point visual estimation	Hiesmayr et al. (2009)
10 hospitals in Tabriz, Iran	46.87	Measured	Taghipour and Mosaferi (2009)
3 hospitals in UK	24–39	Measured	Sommino and McWilliam (2011)
1 university hospital in Amsterdam	38	Measured	Roosemalen et al. (2012)
1 university hospital in Denmark	11–18	Measured (lunch and supper)	Oferi et al. (2014)
<i>Overall food waste</i>	Median 31 (6–65) N = 45		

### 3 Results and solutions

After reviewing many studies for food or plate waste in hospitals, the resulting 35 articles provided percentages for food waste generated, and the remaining articles provided solutions to reducing waste. Other studies relative to waste in terms of energy value or protein content were not covered here. Table 1 shows the percentages of food waste from patients in different hospitals, ranging from 6 weight % to almost 65 weight %, but more typically between 15 weight % and 35 weight %, with a median food waste of 31 weight %. These differences among hospitals depend on the situation of the patients, the services, or the menus. Table 1 summarises most studies in many countries during the past years until September of 2015.

**Table 2** Summary of five articles that quantified food waste solutions and improvement (37 articles provided qualitative improvements)

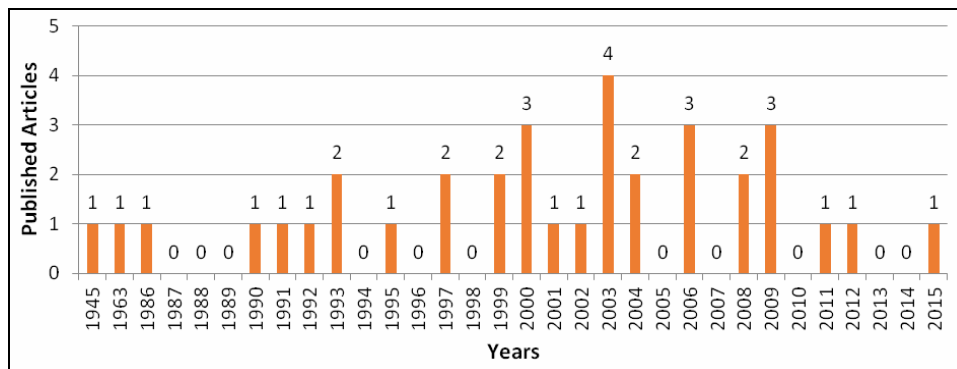
<i>Reference</i>	<i>Percent improvement</i>	<i>Solutions for hospital food system improvements</i>
McLymont et al. (2003)	Before program implementation 39% of patients surveyed consumed greater than 50% of their main entrée. After program implementation 88% of patients surveyed consume greater than 50% of their main entrée (49% improvement)	Policies and procedures were developed, and menu items were tested
Ewalt et al. (2011)	Average decrease of 27.4% in food waste per tray	Menu and system changes positively impacted food waste
Marlette et al. (2005)	15% of food waste from students who did not purchase competitive food items and 30% of food waste from students who did purchase (15% improvement)	Analysis of food wasted by type led to school waste reduction by changing preparation or types of food
Connors and Rozell (2004)	Percentage of food waste reduced from 42% to 32% during first phase (August 2001) and second phase (August 2002), respectively (10% improvement)	Changes in food offered were based on detailed observation of what was wasted and led to reduction in waste
Frakes et al. (1986)	Mean percentage waste of all food served was 21.3% and for pre-plates was 25.5% (4.2% improvement)	Cook-freeze restaurant menu system in hospital led to low waste

Table 2 provides some solutions and improvements to reduce hospital food waste. Approximately 37 studies discussed these issues, but only five of them included the percentage of improvement to reduce food waste. One of the solutions to the problem of food waste is portion size, which was mentioned in some studies. Table 2 includes only articles with the recorded percentage of improvement and their solutions, but other papers discussed solutions with no percentage of improvement recorded, and these are shown in Figure 2.

As can be seen in Table 2, in the five articles that quantified food waste solutions, the improvement range was between 4.2% and 49%. Reasonable improvement, addressed by McLymont et al. (2003), was determined by using the Memorial Sloan Kettering Cancer Center (MSKCC) STRAIGHT-A process to facilitate performance improvement. After applying the rules and changing the menus, improvement increased from 39% to 88%, a 49% improvement. Ewalt et al. (2011) found an average of 27.4% decrease in food waste

per tray after modifying the menu and making system changes, and they determined that the minimum improvement of 4.2% could be achieved by using a cook-freeze restaurant menu system as mentioned by Frakes et al. (1986). Most of these improvements involved the menu as well as type of food or procedure that might be involved in reducing food waste. From these improvements, hospitals could reduce about 21% of their food waste. Therefore, if hospitals develop and improve their menus, service system, and training staff, then food waste would be reduced from 31 weight % to be about 24 weight %. These percentages relative to improving food waste have different scales of measurement. For example, Dubois (1990) used a six-point visual estimation scale developed by Comstock. As shown in Figure 2, food waste might not have been the focus of researchers because the collecting the data consumed too much time, as mentioned in the introduction section. Hospital food waste studies have been published at a rate of about 1–2 per year since 1945. Most of these studies were done between 1999 and 2009.

**Figure 2** Published articles from 1945 until September 2015 (see online version for colours)



**Figure 3** Number of hospitals versus the countries studied (see online version for colours)

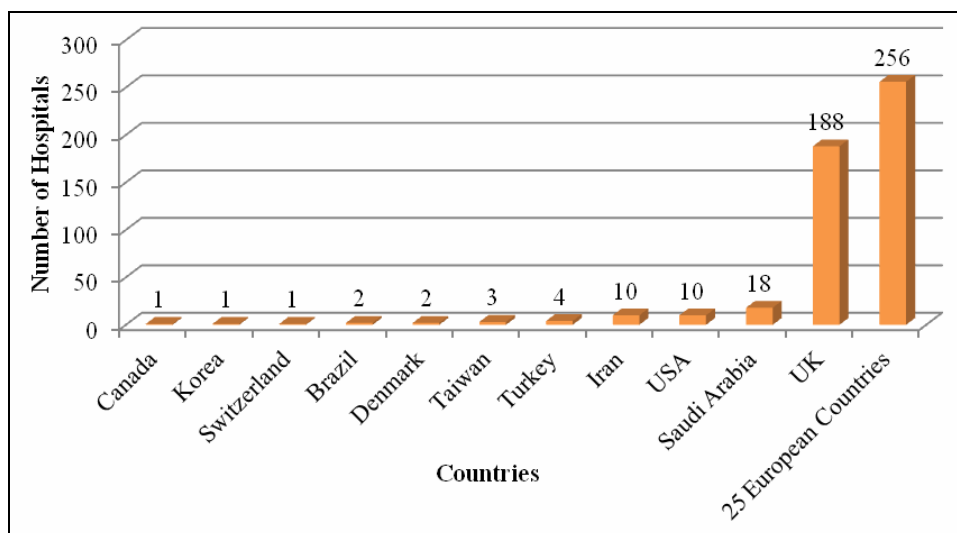


Figure 3 shows that 25 European countries had the most hospitals, or 256, performing food waste studies in previous years (Hiesmayr et al., 2009). The UK and Saudi Arabia alone had 188 and 18 hospitals, respectively, involved in food waste studies. An overlap in these studies involves the UK, Denmark, and Switzerland, which are considered European countries, and the study by Hiesmayr et al. (2009) did not mention which 25 countries participated in those studies. The USA and Iran both had ten hospitals that studied food waste, which seems low compared to the rest of the world. Overall, the total number of hospitals involved in food waste studies is about 500 hospitals in different countries. This figure indicates those countries that are interested in publishing hospital food waste articles realise that this is an issue, whether financial or environmental, that must be solved.

**Figure 4** Number of similar improvements versus type of improvements (see online version for colours)

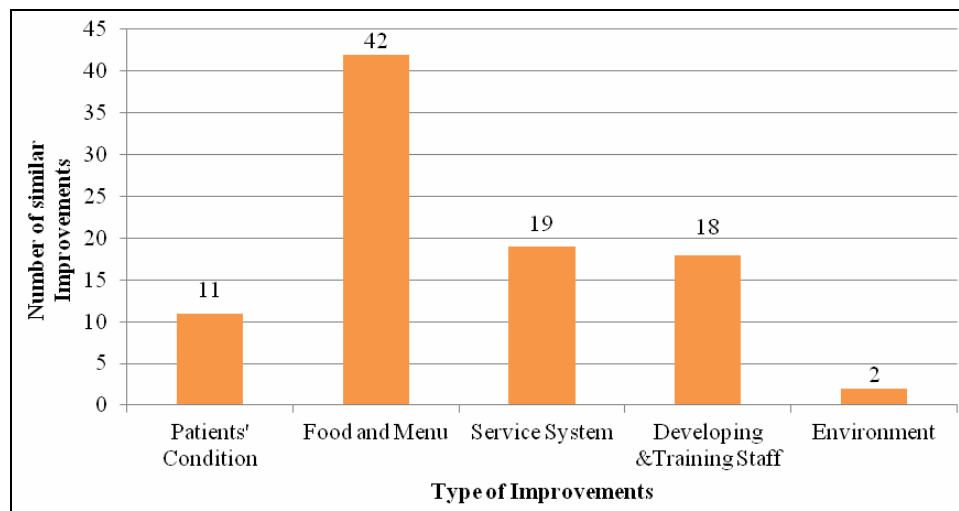


Figure 4 shows the five improvement categories whereby food waste can be reduced, and how frequently these are reported in the literature:

- patients' condition, which includes their appetite and needs, such as flavour and diets
- food and menu, which includes portion-size options, ordering, more menu choices, quality of food, and food style
- service system, including packaging, assistance in ordering meals, delivery system, and meal time
- developing and training staff, which includes knowing the meaning of food waste, policies and rules; quantity of food cooked by monitoring, observing, and recording; and improving catering practices and communications
- environment, including the eating location and surrounding noise.

Most improvements involved food and a menu that patients prefer. The second most frequent improvement suggested was in the service system, and developing and training



staff. Patients' condition was repeated 11 times in the literature review, and finally environmental conditions were mentioned twice in the literature review. Hartwell and Edwards (2003) reported the improvement in the delivery system and how patient satisfaction improved, but food waste increased because there was poor communication between patients and kitchen staff. Some papers mentioned two or more categories for improvement at the same time.

#### 4 Conclusions

Food waste reduction is considered an important issue that hospitals can use to improve sustainability, by lowering the environmental impact from food production to final landfilling of uneaten food. Analysing food wasted and by changing the ways food is prepared leads to greater waste reduction. High percentages were recorded in many of the literature review studies, suggesting more research and support is needed to improve the reduction of food waste. However, it might be impossible to achieve zero waste because of complex reasons for why waste happens, especially when dealing with sick patients. The number of hospitals that have been included in the studies is considered low based on the number of hospitals in the world. Countries should pay attention to the sources of the food and keep track of the food waste that has been increased in some hospitals. Food waste should be monitored and controlled for each meal that has been served to the patient. Monitoring and improving hospital facilities may help to reduce food waste. Also, by knowing the reasons for food waste and applying all possibilities to change whether the service system, menus, time serving, patients' needs, training staff, communications, quality of food and preparation can lead to a reduction in food waste.

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