8 DISCUSSION

8.1 Objective 1 - What is the overall prevalence of HAI and the specific types of HAI in adult inpatients in acute and non-acute hospitals in Scotland?

This first national survey of the prevalence of HAI of 13 754 adult inpatients in acute and non-acute hospitals in Scotland was undertaken by a team of investigators based within the SSHAIP team at HPS who were fully trained in the survey methodology, including HAI definitions. Data collection tools developed for the survey, monitoring and validation of data collection aimed to ensure the robustness and consistency of the data. All 45 acute hospitals and a representative sample of 22 non-acute hospitals in Scotland were included in the survey.

This survey examined the burden and prevalence of HAI and is the first of its kind to do so at a national level, including all hospitals in the acute sector and 25% of patients in the non-acute setting.

8.1.1 Acute hospitals overall prevalence

The prevalence of HAI in patients in acute hospitals was found to be 9.5% (95% CI 8.8-10.2). The differences in populations sampled and in survey methodology which make comparisons of the results of HAI prevalence surveys inappropriate have been fully enumerated by Gastmeier (48) and are summarised in the literature review (Appendix Table 1-1 page 160). These include differences in the populations studied (hospital type and practice, year of study, type and case-mix of patients) and methodological issues, including HAI case definitions and their application in case ascertainment. It is coincidental, therefore, that this 9.5% prevalence estimate in acute hospitals is similar to that reported in UK surveys in 1980 (5) and in 1993-4 (49). The population studied in this Scottish survey was however, older than those studied in these two UK studies. More recently a HAI prevalence survey of acute hospitals has been undertaken in England, Wales, Northern Ireland and the Republic of Ireland (25-28) (the HIS survey in 2006), over a four month (February to May) period during the year the Scottish survey was undertaken, which used the same HAI definitions (18). In this survey of volunteer hospitals a prevalence of 7.6% (combined England, Wales, Northern Ireland and the Republic of Ireland) was reported in a survey of 75,765 patients in 273 acute hospitals. However, even in this survey there are differences in patient case mix and aspects of the methodology which mean that a comparison of the unadjusted, overall HAI prevalence with that reported here should be undertaken with caution.

Most prevalence surveys (22, 25-28) concentrate on a subset of HAI types these often include four infections: pneumonias, urinary tract infections, surgical site infections and blood stream infections. This survey found an overall prevalence in these infection types of 5%. However this survey found that these types of HAI were not the most common and accounted for only about half of all the HAI identified.

Inpatient populations can, however, be summarized in terms of the proportion of survey population greater than 64 years. It is important to note that the inclusion criteria within each of the 3 prevalence surveys undertaken in the UK were slightly different. Using this approach, 64.8% (63.6% for Acute, 70.9% for non-acute) of Scottish inpatients were 65 or older, a considerably older population than that reported by Meers (5) (42.7%) and Emmerson et al (6) (55.7%). The recent HIS Survey indicated that England, Wales and Northern Ireland had similar proportions of patients over 64 years, the Republic of Ireland showed a slightly younger inpatient population (28). The population in a prevalence survey is differnet from that of an incidence survey. ISD incidence data show that 49.1% of the hospital population are over 64 years old.

The logistic regression models created may be used to calculate the expected prevalence rate in a population for comparison with the observed prevalence rate. This comparison would take into account the distribution of the variables in the population that were found to affect the prevalence rate in the models.

8.1.2 Acute hospitals prevalence by hospital type, specialty and ward type

Prevalence varies according to the patient population in a hospital, specialty and ward and the interventions patients undergo within that setting (see Figure 6-6 page 57 and Figure 6-9 page 59). Each of these will be discussed in turn.

Other studies (5, 6, 19) have indicated that hospital type has an effect on prevalence of HAI. In this study, there appeared to be a difference in prevalence of HAI between Obstetric hospitals and other types of hospital (see Figure 6-8 page 59 and Appendix Table 5-18 page 204). However, HAI prevalence did not vary significantly between large, medium and small acute hospitals (see Appendix Table 5-19 page 204). This may be a reflection of case mix variation and specialty variation. Specialty HAI prevalence was therefore also examined.

Various studies (5, 6, 19-21, 50) have reported variation in HAI prevalence by specialty. This survey found the highest prevalence of HAI in acute hospital inpatients was found in the specialties Care of the Elderly (11.9%), Surgery (11.2%), Medicine (9.6%) and Orthopaedics (9.2%), (Table 6-12). One implication of this observation is the importance of emphasising hospital wide infection control policies and practice, such as standard precautions, which can reduce the prevalence of a wide range of HAIs.

As expected, the highest prevalence of HAI was found in ICU and HDU wards due to the immunocompromised nature of the patient population and the invasive nature of the multiple interventions performed in these settings. The prevalence found within ICU wards was 27.1% (95% CI 19.2-35.1) and in HDU was 16.5% (95% CI 10.4-22.6). Within general wards prevalence was 9.2% (95% CI 8.5-9.9).

8.1.3 Acute hospitals HAI type

In this survey the most commonly recorded HAI among acute hospital patients were, in order of proportions of all HAI found: Urinary Tract Infections (17.9%); Surgical Site Infections (15.9%); Gastrointestinal Infections (15.4%) and Respiratory Tract Infections (11.2%). Skin and Soft Tissue (11.0%) were also prominent.

Many HAI prevalence surveys have focused on the historic 'main types' of HAI including the most recent HIS survey (18). The data collectors in the Scottish survey were trained to be precise and accurate in collecting information about all types of HAI. Moreover they were provided with a data collection tool that included all the criteria for the CDC definitions of all types of HAI and these were accessible at the time the data were being collected.

This study indicates that the pattern of proportions of HAI appears to be different to previously published studies. Fifty two percent of Gastrointensinal Infections had organisim data recorded, of those 95% were *Clostridium difficile*. This is likely to be explained by recent initiatives throughout the UK on standardising microbiology testing and mandatory surveillance, which focus on *Clostridium difficile* in hospital patients (29). Eighty percent of *Clostridium difficile* infections recorded occurred in patients in the General Medicine and Care of the Elderly specialties (Appendix Table 5-9 page 196). However microbiology reports were unavailable for 44% of inpatients diagnosed with gastrointestinal tract infections at the time of survey. Due to the fact that CDC definitions of HAI do not require positive microbiology to make a positive diagnosis, it is likely that many of the 44.0% of all gastrointestinal infections were due to norovirus (NV).

The surgical site infection data are also of interest in terms of microbiology. A third of all *Staphylococcus aureus* microbiology data recorded was for SSI. Of all the microbiology data collected for SSI, 52% was *Staphylococcus aureus* and 70% of these were MRSA. The majority of *Staphylococcus aureus* infections (70%) occurred in patients in General Medicine and Surgery specialties (Appendix Table 5-9 page 196).

Comparisons of the types and proportion of HAI reported in other studies (3, 5, 17, 19-23) are confounded not only by the differences in population case-mix and methodology noted above but also by an emphasis customarily placed in HAI incidence and prevalence studies on recording only certain 'major' HAIs viz: Urinary Tract infections, Surgical Site Infections, Pneumonias and Blood Stream Infections. In the Scottish National HAI prevalence survey these made up only 47% of all infection types. In this study, Pneumonias accounted for 8.8% of HAI and Blood stream Infections for 4.4%. The impact of different types of HAI in terms of increased LOS and cost is discussed later. What is noteworthy in the results of this survey is that the spectrum of HAI occurring in acute hospital patients is wide. This is also the case at the level of individual specialties. Most, if not all types of HAI occur in patients in every specialty. However, as would be expected, patients in some specialties have a higher prevalence of HAI than others. It may be that frequent patient movement between wards as part of bed management may result in the more widespread occurrence of HAI.

It is also worthy of note that multiple infections were found in 1.1% of all inpatients (or 11.4% of acute hospital inpatients with HAI). These findings reinforce the differences between inpatient populations in each healthcare environment and, for similar reasons, emphasise that prevalence of patients with multiple infections reported in previous surveys should only be compared

with caution. Meers et al (5) found that 5.6% of HAI inpatients had more than one HAI, but surveys in Germany (19), Italy (20), Switzerland (23) and Slovenia (17) suggest that this statistic can range from 4.1% to 21.2%. This broad range is probably indicative of differences in survey methodology and diagnostic rigour, as much as differences in the surveyed populations.

8.1.4 Non-acute hospitals overall prevalence

The prevalence of HAI in patients in non-acute hospitals was found to be 7.3% (95% CI 6.0-8.6), i.e. lower than that in acute hospitals. Differences in the specialty distributions and case-mix in the acute and non-acute hospital populations may account for this difference.

8.1.5 Non-acute hospitals prevalence by hospital, specialty and ward type

There are few surgical patients in the non-acute hospital population while psychiatric patients, a group with a relatively low prevalence of HAI (5%), make up just over 50% of the population. In other reports (51, 52) where HAI prevalence has been found to be similar or higher than that in acute hospitals it is very probable that differences in the population sampled e.g. age and case-mix, and in methodology, account for the differing result (Table 6-14 page 70).

8.1.6 Non-acute hospitals infection types

HAI infection type contributing to the burden of HAI in non-acute hospitals was different to that in acute care (Appendix Table 5-10 page 197). Among non-acute hospital patients Urinary Tract Infections were frequent, but as frequent were what could be considered a minor, but no less distressing type of HAI - Skin and Soft Tissue (SST) Infection. Taken together these affected about four percent of the inpatients and almost two thirds of psychiatry HAIs were SST or UTI. The most common organism recorded in these cases of HAI was *Staphylococcus aureus*, of which approximately a third were MRSA. Another frequent infection was GI. It is worthy of note that all of the GI infections with a positive microbiology report (65%) recorded in non-acute hospitals were attributable to *Clostridium difficile*. Almost all of the *Clostridium difficile* (92%) infections were found in patients in the Care of the Elderly and General Medicine specialties (Appendix Table 5-10 page 197). It is also worthy of note that 35% of those diagnosed with gastrointestinal tract infections in non-acute hospitals had no microbiology reported at the time of survey. Again, a large proportion of these 35% could be norovirus but no microbiological reports were available at the time of survey. Multiple HAI infections were found in 1.0% of non-acute inpatients (i.e. 4.5% of non-acute hospital inpatients with HAI had more than one infection).

8.1.7 Multivariate logistic regression analysis

Several factors independently affect HAI prevalence in both acute and non-acute hospitals (Table 8-1). Although seasonality is important in acute hospitals, it is important to note that the seasonality investigation was not possible for non-acute hospitals. It is quite possible that the lack of seasonal effect found in non-acute hospitals shown on Table 8-2 is due to the fact that the majority of non-acute hospitals were surveyed within a single quarter. (see discussion on Feasibility page 144).

***Table 8-1:** Acute Hospitals. Variables affecting HAI prevalence*

Variable	Acute Hospitals
Specialty	Y
Age	Y
Gender	Y
Quarter	Y
Hospital Size	N
Admission Type	N

***Table 8-2:** Non-acute Hospitals. Variables affecting HAI prevalence*

Variable	Non-acute Hospitals
Specialty	Y
Age	Y
Gender	N
Quarter	-
Hospital Size	N
Admission Type	N

8.1.8 Objective 1 recommendations

Further analyses need to be undertaken on the burden study component of the study (at specialty level) to examine the impact of co-morbidities that may affect prevalence of HAI. Co-morbidities can be analysed in future by collecting ISD discharge codes for patients included in the survey. It is recommended that this should be considered in future work, and that analysis is undertaken on data from inpatients included in the burden study to examine the impact of morbidity, as reflected in discharge diagnosis, on the prevalence of HAI.

Key Summary Points

Acute Hospitals

- Prevalence of HAI in patients in acute hospitals was 9.5% (95% CI 8.8-10.2)
- The highest prevalence of HAI in acute hospital inpatients were found in the specialties Care of the Elderly (11.9%), Surgery (11.2%), Medicine (9.6%) and Orthopaedics (9.2%)
- In acute hospitals the highest prevalence was found in ICU and HDU wards
- The most common HAI in acute hospital inpatients were Urinary Tract Infections (17.9%), Surgical Site Infections (15.9%), Gastrointestinal Infections (15.4%), Lower Respiratory Infections (11.2%) and Skin and Soft Tissue Infections(11.0%)
- The most common organisms identified in inpatients with HAI, where these data were available were *Staphylococcus aureus* (105 cases) [71 cases of Meticillin resistant *Staphylococcus aureus* (MRSA) and 34 cases of Meticillin sensitive *Staphylococcus aureus* (MSSA)] *Clostridium difficile* (88 cases), followed by *Coliforms* (34 cases)

Non-acute Hospitals

- The prevalence of HAI in patients in non-acute hospitals was 7.3% (95% CI 6.0-8.6)
- In non-acute hospitals, one in ten inpatients in the two specialties, Medicine and Care of the Elderly (combined) was found to have an HAI and one in twenty inpatients in the specialty Psychiatry was found to have an HAI
- In non-acute hospital patients Urinary Tract Infections were frequent, but as frequent were Skin and Soft Tissue Infection. These affected about four percent of the inpatients
- The most common organism recorded in these cases of HAI, where these data were available was *Staphylococcus aureus*, of which approximately a third were MRSA. Almost all of the *Clostridium difficile* (92%) infections were found in patients in the Care of the Elderly and General Medicine specialties

8.2 Objective 2 - What is the impact of HAI in terms of length of stay on NHS activity?

8.2.1 Calculating LOS

Calculating LOS is a complex task and the methodology employed to calculate additional stay has a great effect on the additional LOS calculated (53). Freeman and McGowan (46) found that, measured in the same way in prevalence and incidence series, 'the consequences of nosocomial infection in prolonging hospital stay will appear to be almost twice as severe in a prevalence series' compared with patients who had their discharge data collected from monthly summaries of discharges.

Freeman and McGowan also point out that the hospital population is very different from the whole population of the country. While hospital based studies are of scientific interest, it must be remembered that the patients found in hospital are not directly comparable to similar demographic groups. For example, in men over 60 years the hospital population are more likely to have certain underlying diseases in addition to their reason for admission (53).

In their incidence survey of HAI in one acute hospital in England, Plowman et al (3) reported that the LOS of patients with HAI was 21.7 days compared with 7.6 days for patients without HAI (That is a LOS 2.8 times greater for patients with HAI compared to those without). Freeman and McGowan (46) found that the average prolongation of hospital stay recorded for the same group of patients in an incidence study was 7.3 days compared with 13.3 days when estimated in a prevalence survey. Patients who have longer LOS have an increased risk of HAI, not only due to a longer period in hospital, but also because of an increased vulnerability to HAI due to underlying infection (54). In prevalence surveys the overrepresentation of patients with longer hospital stays contributes to the higher estimates of additional LOS.

Several factors including age, gender and number and severity of underlying disease affect the LOS of patients. It is argued by some (55) that the additional LOS due to HAI which is reported in the literature can be attributed to the underlying disease and a resulting vulnerability not only to HAI but to other complications. Indeed, estimates of LOS derived from physicians' direct costing of the additional LOS result in estimates which are even lower than those obtained from incidence studies. Haley (56) also found confounding effects on LOS estimates of five secondary diseases, viz. obesity, pulmonary embolism, renal failure, diabetes and chronic lung disease. Glynn et al (57) argue that it is events in hospital such as interventions which have the greater effect on additional LOS. Suffice to say that the impact of underlying disease is still debated. In their paper, Freeman and McGowan state that 'the duration of the extra hospital stay caused by nosocomial infection after it occurs is slightly, if at all, related to underlying disease even though such diseases have been identified as strong predictors of the risk of infection.

From ISD published bed days for all inpatients, it is apparent that the findings of this study are quite different from their published mean LOS for each specialty (Table 6-51 page 108). This is supported by other studies calculating LOS using prevalence surveys (46, 56, 58). French and Cheng (58) in a study conducted in Hong Kong using prevalence to estimate the cost of HAI found that the LOS for patients without HAI was 23 days and with HAI was 46 days which is the same as found in the current study (double increase in LOS for patient with HAI).

8.2.2 Adjusted best estimate of increased LOS due to HAI comparable with the inpatients data from ISD

Table 6-49 (page 106) shows that LOS varies by specialty. The increase in LOS for each specialty is 70% using the best estimate for increased LOS. In Urology and Obstetrics, three and four additional days respectively are shown compared with Care of the Elderly with 14 additional days. Based on ISD bed days data for each specialty (59) this estimate appears to be reasonable.

It is clear that there is a wide variation between specialty for increased LOS with Care of the Elderly being the longest with 13.7 additional days and obstetrics being the shortest with 3.2 days additional stay. These LOS estimates are confounded by the co-morbidity status of the patients within these specialties.

For the economic analyses, only patients who had been in hospital for between greater or equal to two days and seven days or less were included in estimating additional LOS due to HAI. This was an attempt to get as close an estimate for LOS as the incidence data suggest. This minimised the bias resulting in prevalence estimates for all patients being adjusted from 27 days to 6.6 days.

8.2.3 Objective 2 recommendations

Further work is required to analyse the prevalence data collected within this survey with the Information and Statistics Division (ISD) International Classification of Disease 10 (ICD-10) data (from the Scottish Morbidity Register 1 (SMR1) when it is collated (45)) which would provide information on co-morbidities and allow a more detailed logistic regression analysis to be undertaken.

The results of this prevalence survey are valuable in estimating costs. However, consideration should be given to incorporating LOS analyses into ongoing incidence surveys.

Key Summary Points

- Calculating LOS is a complex task, the methodology employed to calculate additional stay has a great effect on the additional LOS calculated
- The best estimate of increase in LOS is obtained by using a reduced sample of patients who had been admitted between 2 and 7 days
- This results in a 70% increase in LOS for patients with HAI
- The increase length of stay due to HAI ranged from 3.2 days in Obstetrics to 13.7 days in Care of the Elderly
- Morbidity data which are currently unavailable will be included in further analyses of factors affecting HAI prevalence and increase LOS

8.3 Objective 3 - What are the hospital costs associated with HAI in Scotland and how much cost saving would be anticipated as a result of HAI control?

8.3.1 Context

There are two main undesirable consequences of a patient acquiring a HAI while in hospital:

(i) the impact on the health of the patient (reduced quality of life and possibly reduced survival)

(ii) increased treatment costs and prolonged hospital stay

In terms of the cost, one of the main UK studies to date was the Plowman report (3) commissioned by the UK National Audit Office who used an incidence study to estimate the hospital cost to be in the region of £1 000 million per year in England. A recognised weakness of this work was that it was based on a study of a single hospital in England in the early 1990s; while extrapolation of the results may suggest broad orders of magnitude, these become less relevant when applied to other settings and when practice changes.

8.3.2 Length of stay analysis discussion

The present study was not specifically designed to estimate the cost in the same way as the Plowman report, but it was acknowledged from the outset that an estimate relevant to Scotland based on current practice would assist in policy formulation. With this in mind, length-of-stay was selected as the statistic that could most readily and accurately be collected at an individual patient level without requiring significant additional resources for data collection.

The additional LOS is unlikely to be perfectly correlated with the true additional costs of acquiring a HAI while in hospital – for example, the additional costs are likely to involve additional pathology tests, medicines and other treatments, and increased staff time (notably nursing care). A specifically designed study could set about collecting data on all of these factors but this was beyond the scope of a prevalence study. The results suggest areas in which further research might be considered (see Objective 3 recommendations page 127).

However, the selection of additional length-of-stay as a proxy for all resource use associated with a HAI poses additional problems. The first set of problems relates to the censoring of data and these have been discussed in the statistical section of the report. The second set of problems relate to making allowance for all of the other factors that can influence LOS.

Many (possibly most) of the variables that affect LOS could only be measured in a specially designed incidence study (surveying all ward types and recording all HAI types), which would be very expensive to carry out. For example, the specialty of the ward indicates something about the type of illness the patient was suffering from, but it is not a simple relationship. The number of co-morbidities is likely to increase with the age of the patient but the correlation is

not perfect. Older patients are less likely to have suitable supportive discharge arrangements, and so on. Many of these factors are extremely hard to quantify (e.g. patient's ability to cope and whether they have a suitable place to be discharged to). Co-morbidity can be investigated using ICD10 codes which are collected by ISD. However during this study the time delay in hospital records departments coding discharged patients meant that the current study was unable to address these co-morbidities at time of writing (see Feasibility section page 144).

In the 2004 Scottish Executive policy statement 'Building a Better Scotland', the 'efficient government' initiative was launched. (http://www.scotland.gov.uk/Publications/2004/11/20318/47372). This proposed savings be divided into those that were cash-releasing (cash-releasing efficiency savings, or CRES) and those that freed resources for other purposes but did not release cash (time-releasing efficiency savings, or TRES). The savings from tackling infections acquired in hospital are most likely to be TRES, since hospital costs are fixed in the short-term to medium-term when workload changes. The time that is released by reducing HAI could be used to improve patient care either by for example, reducing waiting times and making more effective use of skilled professional staff.

8.3.3 Economic analysis approach

The prevalence approach used the whole dataset but the approach to sampling created problems by over-representing the people with a long LOS. The approach using model 2 and a reduced sample of patients to calculate LOS used above (see section 6.12 Length of stay estimate for economic analyses page 103) corrects for this to some extent but at the cost of excluding everyone with a LOS of less than two days. Given that the average stay in some specialties is only 3-4 days, this can be a sizeable minority of patients and it tends to increase the average stay for those without a HAI.

8.3.4 How does this figure compare to earlier estimates?

Table 8-3 compares some recent estimates of the added cost of HAI and compares them to the current study:

Table 8-3: *Comparison of economic estimates of cost of HAI estimated by previous studies*

	HAI %	Added stay days	Added cost £	Total cost £ million
Scottish Office 1999 (60)	9	2	314	22
Plowman 1994 (3) (Incidence)	7.8	11	2 917	101
Walker 2001 (13)	9.2	11	2 244	186
This study 2007	9.5	6.6	2 105	183
This study 2007 using the full average cost per stay	9.5	6.6	3 003	262

Adjusting the Plowman and Walker figures to 2005/6 figures using the Hospital and Community Services Pay and Prices Index gives totals of £146m and £196m respectively. This study estimates that the most plausible figure for overall cost of HAI per year to the NHS to be £183 million (Table 6-56). Estimates based on 95% CI of prevalence as estimated in this survey gave a range from £170 million to £197 million.

It is notable that estimates of the proportion of patients who acquire HAI is fairly consistent across the studies. However, the estimates of increased LOS show considerable variation, as discussed elsewhere in this report but the added cost per HAI is also relatively consistent.

8.3.5 Objective 3 recommendations

In order to generate the most accurate estimates of the cost of additional stay two things would be desirable:

1. A cohort study of people admitted to hospital that allows incidence to be estimated – if the costs in different specialties are of interest (e.g. haematology, oncology) this should be taken into account in designing the sampling framework
2. A more accurate estimate of the cost of added days of stay related to a HAI

However these would require costly and time-consuming studies. It is recommended that the prevalence survey should proceed to re-analyse the prevalence data using ISD discharge data including information on the patients' disease classification (ICD-10), which would allow a more specific comparison of patients with and without HAI. This data was not available at the time of writing.

It is recommended that the ICD-10 data when available is incorporated into the analysis.

Key Summary Points

- Costs of HAI in Scotland are estimated to be £183 million per year for all the specialties
- The cost of HAI in individual specialties ranges from £2 million per year (Obstetrics and Urology) to £49 million (Medicine)
- A more detailed analysis could be undertaken using ISD data, which was not available at the time of writing
  - It is recommended that the prevalence survey data are re-analysed using ISD ICD-10 discharge data
- If a reduction of HAI by 25% could be made within the surgical specialty an estimated 4 814 additional cases per year could be treated

8.4 Objective 4 - Prescription of antimicrobials 48 hours after admission to hospital as a proxy indicator of HAI

Thirty two percent of all acute hospital inpatients were prescribed antimicrobials at the time of the prevalence survey (Table 6-18). In non-acute hospitals, 15.6% of inpatients were prescribed one or more antimicrobials (Table 6-21).

The numbers of HAI in patients who had been prescribed any antimicrobial 48 hours or more after admission to hospital (Group 1) was significantly greater ($P<0.0001$) than the number of HAI in those who had not been prescribed any antimicrobial at the time of survey or who had been prescribed antimicrobials less than 48 hours after admission (Group 2) (Table 6-57 (page 113) and Table 6-58 (page 113)). Sensitivity of over 80% was found in acute hospitals and over 90% specificity in both acute and non-acute hospitals. However the positive predictive value was found to be around 50% in both acute and non-acute hospitals. It is clear that there is potential merit in using this as a test for HAI and it could provide a useful tool for hospital epidemiology.

Hospital Pharmacy departments could potentially provide regular reports on the number of inpatients who have been prescribed antimicrobials 48 hours or more after admission, which could be shared with the infection control teams at relatively little cost and time compared to prevalence surveillance (See Table 7-2).

8.4.1 Objective 4 recommendations

Undertaking a more detailed incidence study of all hospital inpatients over a given time which records the number of new cases of HAI during a given period, would give a more detailed picture. To undertake a similar analysis to the one included here, all the antimicrobials prescribed to an inpatient during their hospital stay would need to be recorded. Incidence studies are expensive in terms of time and cost and are generally undertaken in specialised units or on groups of inpatients who have undergone a specific procedure.

Key Summary Points

- There was a statistically significant difference in the prevalence of HAI between patients who were given an antimicrobial 48 hours after admission compared with those who did not
- Using antimicrobials as a proxy indicator of HAI provides a test with both sensitivity and specificity >80%; but positive predictive value of approximately 50%
- These results are encouraging and a more detailed study is recommended to investigate the use of antimicrobial prescribing as a diagnostic test for hospital wide epidemiologic surveillance

8.5 Objective 5: How do the incidence estimates obtained from prevalence measured in this survey compare with the results of targeted incidence surveys?

Prevalence data are a cost effective and timely way of gathering information of HAI. Incidence studies are more expensive and take longer to complete. On this basis, using prevalence data to generate the same information as incidence surveillance would be a cost effective approach.

There is some literature which suggests that prevalence data can be converted to incidence data. Two key papers (43) and (61) discuss the mathematical relationship between prevalence and incidence. These models describe incidence as 'prevalence divided by the duration of a HAI or an estimate of duration of infection'. However, these models are only valid if LOS is exponential and in the current study it is log normal. Graves et al (62) have applied the model and present results which they believe to be acceptable. Gastemeier (63) and Rossello-Urguell (64) advise against the use of the model.

Several authors (62-65) have used these formulae and applied them to the data resulting from HAI prevalence studies. Their conclusions on the applicability of the model in practice are conflicting, and the evidence base for the use of these formulae is inconclusive. Nonetheless the relationship appears to be statistically sound in special circumstances and biologically reasonable and, if an appropriate setting could be found, would be a useful additional approach to surveillance analysis.

As can be seen from Appendix Table 7-1 (page 224), the information available from SSHAIP SSI incidence data were of limited value for a number of reasons. Not all of the categories of surgery included in the incidence programme were found in the prevalence survey (i.e. insufficient numbers), and when these procedures were mapped there were only three categories of surgery that had sufficient data for comparison. For these three categories of surgery, calculated incidence was compared with measured incidence. These results were found to be variable: only one category of surgery appeared to have a rate which was comparable, and the others were not comparable.

The final results from the formula may be biased towards higher risk inpatients from medium to large acute teaching hospitals, as only complicated major surgical procedures were compared.

8.5.1 Objective 5 recommendations

From the data available no conclusions can be drawn about the validity of this approach for modelling national incidence surveillance data and further work is recommended to examine this relationship in more detail.

Key Summary Point

- Incidence data from hospitals participating in the SSHAIP incidence surveillance programme were used to compare measured incidence with incidence calculated using the current survey prevalence data
- The comparison was found to be of limited value
- There were only three categories of surgery that had sufficient data for comparison
- For these three categories of surgery, calculated incidence was compared with measured incidence and only one category of surgery (major vascular surgery) appeared to have a value, which was comparable
- Further work is recommended to examine this relationship in more detail

8.6 Objective 6 - What are the priority areas for targeted incidence surveillance?

8.6.1 Implications of the prevalence study for the SSHAIP programme

The current SSHAIP programme of national HAI surveillance was described in Table 2-2 (page 30). This study provides information for the further development of the SSHAIP programme. Priorities for HAI surveillance should be decided on the basis of high volume (total numbers of HAI nationally), high cost (the costs of the HAI nationally) and high risk (the consequences of the HAI to the patient).

8.6.2 Volume

Volume can be represented by numbers of HAIs. The numbers of organisms causing HAI, devices used and specialties in which large number of HAI occur are also important considerations when discussing the volume of HAI. Each of these will be discussed in turn.

The prevalence survey results indicate that the highest proportion of HAI in acute hospitals was: Urinary Tract Infection (17.9% of all HAI); Surgical Site Infection (15.9%); Gastrointestinal Infection (15.4%) (Table 6-10 page 61) (95% of which were caused by *Clostridium difficile*). Respiratory Infection comprising lower Respiratory tract infection (11.2%) and Pneumonia (8.8%) comprise 20% of all HAI. In non-acute hospitals these were: urinary tract infection (28.1% of all HAI); Skin and Soft Tissue Infection (26.8%); Gastrointestinal Infection (12.2%) (Table 6-13 page 69).

Where microbiology reports were available the most common types of organism associated with HAI found in acute hospitals were (in descending order): *Staphylococcus aureus* (MRSA and MSSA); *Clostridium difficile* and *Coliforms*. Thirty one percent of all blood stream infections found were due to *Staphylococcus aureus* (Appendix Table 5-22). In non-acute hospitals the same organisms were most common although proportionally more MSSA than MRSA were reported (Appendix Table 5-24).

The devices which were most the most frequently in situ were peripheral vascular catheters (PVCs), urinary catheters and central vascular catheters (CVCs). These were found in greater volume in particular specialties (PVCs in medicine, CVCs in medicine and surgery, mechanical ventilation in ICU and urinary catheters in medicine, care of the elderly, surgery and orthopaedics). In non-acute hospitals the most common device was urinary catheters.

The large specialties in acute hospitals with the highest volume of HAI were in descending order: Care of the Elderly, Surgical, Medicine (including Renal), Urology and Orthopaedics (Table 6-12) in acute care. In non-acute hospitals these were Medicine, Psychiatry and Care of the Elderly (Table 6-15). Most blood stream infections occurred within inpatients being cared for under Haematology, Oncology, Surgery and Medical specialties (Appendix Table 5-9).

Almost one third of the hospital population were on an antimicrobial (Table 6-18 page 74). Almost 13% of all inpatients in acute hospitals were on multiple antimicrobials at the time of the survey. This represents a high volume of use.

On the basis of volume of cases the priorities for targeted incidence surveillance, would be:

- Catheter associated UTI
- SSI
- *Clostridium difficile* GI infections
- Vascular catheter associated infections (including *Staphylococcus aureus* bacteraemia)

There is also a need to consider specialty level surveillance in medicine and care of the elderly. It might be that vascular catheter surveillance would be particularly useful in these specialties as PVCs were most commonly found in these specialties.

8.6.3 Cost

Costs of HAI have been expressed in terms of specialty specific additional LOS (Table 6-52 page 109). Specialty additional costs per year ranged from £49 million in Medicine and £26 million in Surgery (ranked in the top 2) to £2 million a year in both Obstetrics and Urology (ranked joint lowest).

On this basis targeted incidence surveillance should focus on Medical and Surgical Specialties.

No analysis was undertaken to assess the cost of additional LOS at organism level. The study only collected date on the prevalence of devices and no association can be made between devices and additional LOS due to HAI.

8.6.4 Risk

Risk can be expressed in terms of the impact of the HAI on the patient. There is a large body of medical literature on the topic of HAI and its effect on individual patient morbidity. The Scottish National HAI Prevalence survey reports results on the volume and cost of HAI, however the third and final factor, which must be considered when discussing priority areas for surveillance, is the effect on morbidity and mortality, which is not addressed in the current study. Prevalence surveys are not able to assess the effect on the patients' morbidity and mortality due to the 'snap-shot' nature of the surveillance. In order to make recommendations on where priority should be given for future incidence surveillance; reference must be made to the medical literature in combination with the volume and cost findings from the prevalence survey.

The current prevalence survey only assessed the impact of the HAI on the patient in terms of additional LOS. A proxy indicator for the effect of HAI on morbidity is the additional LOS. The consequences of HAI in terms of additional LOS for the patients include: anger, pain, suffering and ill health, but also serious social consequences such as: a delay in return to work, potential loss of earnings, additional child care costs and cancellation of holidays. HAI increased the LOS in all specialties by 70%. The largest additional LOS was attributable to the specialty care of the elderly with an additional 14 days for those patients on average.

8.6.5 Effect on mortality

This survey has addressed the cost in terms of increased LOS due to HAI occurring in inpatients. There are however other adverse events associated with HAI.

Data from studies in the U S suggested that 10% of inpatients who acquired a HAI subsequently died as a direct result of the infection (66). The studies also suggested that the infection was a major contributory factor in the death of a further 30% of these inpatients. When the figures were extrapolated to the whole of the US population presenting with a HAI over the course of a single year, it was estimated that in 1982, some 20 000 deaths were directly attributable to HAI and that a further 60 000 were indirectly attributable to HAI. This means that, in the US, HAI was the eleventh leading cause of death. When deaths which were both directly and indirectly attributable to HAI were taken into consideration, HAI was considered the fourth leading cause of death.

It is often quoted that in the UK there are an estimated 5 000 deaths per year as a direct result of HAI and that HAI may be a significant contributing factor in a further 15 000 deaths per year (67). A study by Plowman et al (3) found 13% of inpatients with HAI died compared with 2% of those without. Adjusted for age, gender, co-morbidity and other factors, the mortality rate was 7 times higher for inpatients with HAI. These data are the best available approximation of mortality. However they are now quite out of date (in terms of population demographics and LOS) and were extrapolated from a single English hospital which did not include all the specialties seen in Scotland and, as such, there is a need for more robust data in Scotland in this regard. The SSHAIP programme should include special studies in this regard so that risk can be more adequately examined. On the basis of risk, as defined by additional LOS, priority areas for targeted surveillance should be in care of the elderly, medicine, surgery and orthopaedics. This may mean there is needed for targeted prevalence as the risk is not specific to one type of HAI.

8.6.6 Prioritising areas for targeted surveillance

The SSHAIP programme of work includes surveillance of *Staphylococcus aureus* bacteraemia (amongst other programmes of work) as a key indicator of HAI (see page 29 for outline of SSHAIP Programme). *Staphylococcus aureus* blood stream infections have a very serious effect on morbidity and mortality for patients and are considered to be largely preventable and therefore are a clear priority for targeted surveillance on the grounds of risk to the patient. It can be seen in Figure 8-1 that *Staphylococcus aureus* blood stream infections represent almost half of all bloodstream infections and a small proportion (1.4 %) of all HAI found

in Scottish acute hospitals, but because of the risk to the individual patient are included in the incidence surveillance programmes. Table 14-4 summarises the priorities for surveillance based on volume, cost and risk of each of the key potential priority areas.

Figure 8-1: *Pyramid representation of HAI types. Showing infection types, 55 blood stream infections in total, 17 of which are have Staphylococcus aureus as the causative organism.*

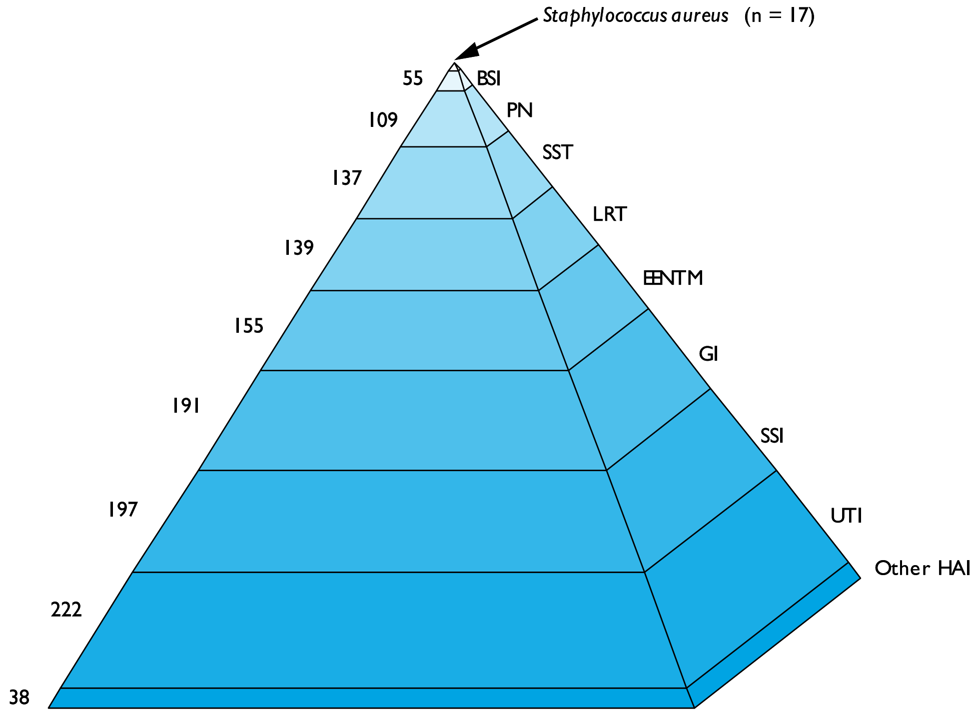

Table 8-4: *Priority areas for surveillance of HAI*

Potential Priority Areas	Volume of HAI (National)	Cost of HAI (National)	Risk (To individual patients)	Prioritise for surveillance (Combined volume cost and risk)
HAI Type				
Surgical Site	✓	✓	✓	✓
Urinary Tract	✓	✓	✓	✓
Pneumonia			✓	✓
Lower Respiratory Tract	✓	✓		
Gastrointestinal	✓	✓	✓	✓
Skin & Soft Tissue	✓			✓
Blood Stream			✓	✓
Specialty				
Medicine	✓	✓	✓	✓
Surgical	✓	✓	✓	
Care of the Elderly	✓	✓	✓	✓
Orthopaedic	✓	✓	✓	
Organism				
C. difficile	✓	✓	✓	✓
S. aureus	✓	✓	✓	✓
Devices				
PVCs	✓			✓
Urinary Catheters	✓	✓		✓
CVCs	✓	✓	✓	✓
Mechanical Ventilators		✓	✓	✓

Ideally, national data should be a by-product of local surveillance systems, and, national and local surveillance systems should be integrated so that no more data are sought nationally than are needed locally. While the overall aims of surveillance at local and national levels may be similar, the emphases vary: at national level there is likely to be more emphasis on the identification and prediction of national trends, and the evaluation of national interventions and control programmes. At the local level, local trends, outbreaks and individual cases of severe illness are likely to be more important, as are the evaluation of local interventions and initiatives, and the examination of local practises in patient care.

As a rule, active comprehensive, individual data systems are the most expensive, but provide the best quality data. In addition, valuable information can be gleaned from special studies (including outbreak investigations) and prevalence surveys. These, strictly, do not constitute surveillance, as they are not ongoing. Regularly repeated prevalence surveys may however be deemed to be surveillance.

8.6.7 Objective 6 recommendations

Targeted incidence surveillance for:

1. Surgical site infection
2. *Clostridium difficile*
3. CAUTI (Catheter Associated Urinary Tract Infection) in medicine, care of the elderly, surgery and orthopaedics and non-acute hospitals
4. Vascular catheter infections
    a. PVC in medicine
    b. CVC in surgery and medicine
5. *Staphylococcus aureus* bacteraemia

Antimicrobial prescribing should also be monitored

Repeated prevalence surveys for:

- specific specialties (elderly care, medicine)
- hospitals with small bed numbers where targeted incidence surveillance is of limited value
- as a cost effective means of measuring the impact of interventions over time (utilising at least 3 surveys pre and post intervention) (21, 68, 69).

Key Summary Points

- National and local surveillance systems should be integrated where possible and evaluated to ensure maximum public health benefit is achieved
- On the basis of high risk, volume or cost; priority areas for incidence surveillance are: Catheter Associated Urinary Tract Infection (CAUTI), Surgical Site Infection (SSI), Gastro Intestinal Infection (GI) specifically (*C.difficile*), Skin Soft Tissue Infection (SST) (related to Peripheral Vascular Catheters (PVC), Central Vascular Catheters (CVSs), and Blood Stream Infections (relating to CVCs)
- Specialty specific surveillance should be considered with regard to the above noted targeted areas in Medicine and Care of the Elderly with potentially targeted prevalence of all HAI
- Special studies on HAI attributable mortality should be undertaken in Scotland

8.7 Objective 7 - Priority areas for intervention

8.7.1 Preventability of HAI

The prevention and control of HAI now has a very high priority within the NHS in Scotland. It is necessary to ensure that this momentum is maintained and that further development is rational and builds on work already undertaken. It is not possible, at least at this time, to undertake comprehensive surveillance of every type of HAI on a continuous basis. As well as identifying the priority areas for surveillance, consideration needs to be given to where the greatest improvements in patient care are likely to come. At the same time issues of resources (staff, IT etc.), suitable methodologies and feasibility need to be taken into account.

Consideration in deciding priority areas for intervention are based on:

- a The effectiveness of the prevention in terms of:
  - i. The volume and severity of HAI types
  - ii. The patient groups affected
  - iii. Where most achievement is possible
  - iv. Where methods of prevention are known to be effective
- b. The cost of prevention

The proportion of HAI, which is potentially preventable, is not known. In the late 1960s epidemiologists in the USA noticed that feedback of information about Staphylococcal epidemics in hospitals could change the behaviour of the physicians, nurses and other personnel in such a way as to reduce HAI (70). A large multi-centre (SENIC) study by Haley et al (1985) (9) suggested that four components were required to reduce HAI: surveillance, control, an Infection Control Nurse to collect data and a physician actively involved. For surgical wound infection specifically, the suggested requirements were intensive surveillance, intensive control and a programme of regular feedback to surgeons. Hospitals which had all of these elements could reduce surgical wound infection rates by 20% over 5 years. Furthermore, hospitals with all of these elements *and* an interested physician could reduce surgical wound infection by 38% in the same time period (9). These findings are commonly referred to in the literature as the basis for surveillance of HAI. These data are now around 30 years old, (the study was conducted between 1971 and 1976) and their applicability are limited by the fact that the study was based on an American healthcare setting. The study has never been replicated out with the USA, however several other smaller studies have been published since by various authors.

In 1995 in the UK, the Hospital Infection Working Group of the Department of Health (DoH) in England (71) suggested that it might be possible to achieve a 30% reduction in HAI. In England in 2000 the National Audit Office (NAO) published a review of the management and control of HAI (67) and indicated through a census of infection control teams that 39% considered a 30% reduction to be achievable, 49% felt it was too high and 12% did not know. The most common estimate of possible reduction was between 5 and 10% of all HAI. The bed weighted average across all NHS trusts in England who participated, was a reduction potential of 15% of HAI.

Recently Harbarth and colleagues (1) have carried out a systematic review of the literature in this field for intervention studies published from 1990-2002. The review focused upon 25 relevant studies conducted in various patient populations and healthcare settings and found the a potential to reduce HAI ranged from 10% to 70%, depending on the setting, study design, baseline rates and type of HAI. Table 8-5 summarises the estimated reduction effect suggested by Harbarth et al. (1).

Table 8-5: *Potential reduction in HAI by type and setting indicated by Harbarth et al (2003)*

HAI type	Reduction potential (range)	Setting details
CVC associated bloodstream infection	14-71%	70% neonates 56% adult critical care
VAP	38-70%	ICUs
Catheter associated UTI	46-60%	All specialties
SSI	24-34%	Surgical specialties

The most common interventions leading to reduction of HAI were surveillance, hand hygiene, education and audit. The review concluded that approximately 20% of all HAI were preventable, but that there was a need for more research to be conducted on multi-modal interventions with careful design consideration including control groups.

Current literature on HAI prevention and control has focussed significantly on the effectiveness of 'care bundles' (72) in terms of interventions to control HAI. In their systematic review of the literature in 2007 Aboelela et al found that bundles of 2-5 interventions were employed in the 33 studies included in the review. The behavioural interventions included in the 'care bundle' approach evaluated in this review were education, formation of a quality team, compliance monitoring, staff performance and feedback and staff development skills and testing. The multi-modal approach does not allow the impact of a single intervention to be examined, however considering the multifaceted nature of HAI, this approach is beginning to be recommended (73) and is worth consideration in those areas of high volume, risk and cost identified in section 8.5 of this report.

The key implications from the literature and the present study, outlined in section 8.6, are that surveillance priorities should be in those areas of high risk, high volume and high cost. In addition, priorities for HAI interventions should also focus on the potential for prevention.

The current work on HAI surveillance in Scotland is being developed into a programme approach to the reduction of HAI in Scotland and as such must include the priority areas with most potential for prevention as identified in Table 8-5.

8.7.1 Priority areas for intervention

> 'Infection-a thing of which people are generally so afraid that they frequently follow the very practice in regard to it which they ought to avoid.'
>
> *Nightingale (1859)*

Healthcare associated infection is in some cases related to inappropriate patient care practices. The impact of these practices on outcome is greater in a healthcare setting than the general population as the patient population may be particularly susceptible to such infections, due to age or co-morbidities. In addition, immunocompromised patients such as infants or patients undergoing chemotherapy are likely to develop more serious disease, and the infection may result in death.

The common types of HAI found in the prevalence study such as urinary tract infections, surgical site infections and skin and soft tissue infections are often associated with healthcare interventions, for example use of catheters and surgery. Interventions vary, based on the needs of the patient population within and between hospitals. Accordingly, there will be a heterogeneity in the causes of HAI within any given hospital, which will necessitate a selection of intervention programmes aimed directly at these common infection types. The priority areas for intervention should be developed to reduce HAI and should be adaptable to individual settings with the overarching principles of directing the infection control resources to where the greatest improvement can be achieved first.

Since HAI can be an unintended consequence of healthcare interventions such as urinary catheterisation, vascular catheterisation or surgical procedures (74), there is a necessity for individual units and hospitals and NHS Boards to provide evidence of optimisation of practices related to these invasive healthcare interventions – any devised intervention programme should assist in this process.

National surveillance data have demonstrated that MRSA bacteraemia remains a problem in Scottish hospitals and, despite enormous efforts at improving infection control managerially and organisationally through the SEHD HAI Task Force programme, there is as yet no significant indication of a reducing incidence. The prevalence survey has demonstrated a continuing burden of HAI in NHS Scotland and it is clear that a specific focus on areas of high risk, volume and cost is required in order to improve quality of care and reduce the incidence of these HAIs.

The focus of these interventions should therefore be aimed at reducing urinary tract infection, surgical site infection, lower respiratory tract infection, gastrointestinal infection and skin and soft tissue infection. The healthcare practices which should be focussed upon in terms of priority should be those such as care and maintenance of devices such as urinary catheters, vascular catheters (peripheral and central) and mechanical ventilation. A focus should also be given to those practices that prevent surgical site infection (pre, peri and post op care), prevent transmission of infection (such as hand hygiene) and prevent and control antimicrobial resistance (such as prudent prescribing of antimicrobials). By targeting interventions in these areas where there is the most potential for prevention, the impact on outcome will be maximised.

8.7.2 Cost implications of targeting priority areas for prevention

The theoretical minimum risk of acquiring a HAI is unknown and requires further investigation. However, based on the evidence currently available, priority areas for surveillance should be those where there is the greatest potential for reduction in HAI rates.

The cost effectiveness of surveillance and other activities aimed at reduction of HAI also requires further investigation but, on the evidence currently available, it would appear that significant cost savings could be made by focussing on priority areas. Harbarth et al (1) indicate that 20% of all HAI in all specialties is probably preventable. This would mean that on the basis of the results from the survey that at any time 9.5% of all inpatients have an HAI, 1.8% (20% of 9.5%) would be preventable.

As an example, in a general surgical ward where the additional cost per patient per day is £308 (see Table 6-51 page 108) and the average additional LOS is 5.7 days, the average additional cost per case of surgical site infection is £1755.60. (This estimate only includes cost while the patient is in hospital and no account is made for additional healthcare costs once discharged). Table 14-6 shows the potential cost savings from various levels of HAI reduction.

Table 8-6: *Possible cost savings for various levels of % HAI reduction from prevention of all HAI, based on a total cost of £183 million.*

% Reduction of HAI	Cost Saving £ millions
10	28.3
20	36.6
30	54.9
40	73.2

If these data are then applied to those derived from the economic component of the prevalence survey, this indicates minimal potential cost savings of (1) £36.6 million (20% of £183 million) and indeed further potential savings might be possible by focussing on the aforementioned priority areas.

In recognition of the burden of HAI, both in terms of morbidity and mortality and its subsequent cost, it can be seen as a performance indicator. Encouraged by the move towards clinically (and cost) effective care provision, the development of performance indicators has progressed rapidly. This has resulted in strategic directives for mandatory participation in surveillance. As such, the resulting data from national HAI surveillance programmes in the UK are utilised within the Health, Efficiency, Access and Treatment (HEAT) target in Scotland and as part of the Health Commission's star rating assessment for hospitals in England.

Staphylococcus aureus bacteraemia (SAB) is an unambiguous marker of invasive infection. At present in the UK, SAB is usually hospital acquired (75). There is an assumption that high rates of SAB are an indicator of Infection Prevention and Control (IPC) performance. SAB also causes significant morbidity and mortality. As such the HAI target in Scotland is a reduction of SAB by 30% by 2010. On the basis that SAB is an indicator of all HAI, if the HEAT target were met, a potential £55 million cost saving could be made in NHS Scotland.

The use of these data in this way within the NHS has resulted in much interest from the media. The use of surveillance data as performance measures has resulted in a high public profile for HAI. HAI rates from surveillance studies are often compared between hospitals, countries and over time, but comparisons of crude infection rates should be made with due caution. Rates may be affected by factors such as differences in numerator or denominator definitions, surveillance methods with different sensitivities and specificities for case detection and different intensities of surveillance activities.

Table 8-7 summarises the priority areas for prevention, cost saving and thereafter those which should be prioritised for surveillance intervention.

Table 8-7: *Priority areas for intervention*

Potential Priority Areas	Potential for Prevention Based on Harbarth 2003 (1)	Potential for Cost savings Based on current survey and Plowman (3)	Prioritise for intervention
HAI Type			
Surgical Site	✓	✓	✓
Urinary Tract	✓	✓	✓
Pneumonia	✓	✓	✓
Lower Respiratory Tract			
Gastrointestinal			✓
Skin & Soft Tissue			✓
Blood Stream	✓	✓	✓
Specialty			
Medicine		✓	
Surgical		✓	
Care of the Elderly			✓
Orthopaedic			✓
Organism			
C. diff			✓
S. aureus	✓	✓	✓
Devices			
PVCs	✓	✓	✓
Urinary Catheters	✓	✓	✓
CVCs	✓	✓	✓
Mechanical Ventilators	✓	✓	✓

8.7.3 Objective 7 recommendations

- The SSHAIP programme should focus with NHS boards on targeting interventions where there is the most potential for prevention of HAI. The results from this study indicate these should be care and maintenance of devices such as urinary catheters, vascular catheters (peripheral and central) and mechanical ventilation. A focus should also be given to those practices which prevent surgical site infection (pre, peri and post operative care), those practices which prevent transmission of infection such as hand hygiene and practices which prevent and control antimicrobial resistance such as prudent prescribing of antimicrobials. By targeting interventions in these areas where there is the most potential for prevention, the impact on outcome will be maximised.

- Surveillance in settings outside hospitals should be considered in order to establish the burden and focus on required interventions for the prevention of HAI in these settings.

- The evidence base for interventions that will impact on HAI infection rates also requires development. There are gaps in the published literature on the effectiveness of single interventions, and well-conducted research studies are required. This should be the focus of the newly established Scottish Infection Research Network (SIRN).

- Further work is needed on the impact of HAI outbreaks in order to collect data on the numbers and types of outbreaks of HAI, the aetiology (where known) and the outcomes of control interventions. Such information would provide a knowledge base of outbreaks of HAI, the organisms responsible, methods of transmission, factors that contribute to outbreaks, and effective control interventions. Where similar problems appear in different locations the experience gained in an earlier outbreak along with new information may reveal answers to hitherto unanswered questions and/or assist in the implementation of effective control measures. This is particularly important as infection control teams in the hospital setting are burdened with the impact these infections have on their time and the subsequent costs associated with the management of these (76).

Key Summary Points

- The study has been a useful approach for identifying future targeting activities for surveillance and areas for intervention
- The priority area for focussing interventions in order to reduce HAI are care and maintenance of devices, (urinary catheters, vascular catheters (peripheral and central) and mechanical ventilation), surgical site infection prevention and prudent prescribing of antimicrobials
- The move towards targeted 'care bundles' for an intervention is worth considering in the priority areas identified in this study
- The importance of standard precautions and transmission based precautions should also be emphasised
- Priority areas for HAI prevention and control will continue to be identified through reviewing the evidence from published studies. There are gaps in the published literature on the effectiveness of single interventions, this should be a focus for SIRN
- Further work is needed on the impact of HAI outbreaks in order to collect data on the numbers and types of outbreaks of HAI, the aetiology where known and the outcomes of control interventions

8.8 Objective 8 - What are the acceptability, feasibility and cost of undertaking prevalence surveys in Scottish hospitals?

8.8.1 Acceptability

Acceptability was defined as: 'the adequacy of the survey to satisfy the, objectives and requirements set in the project initiation document' (77). This report contains the findings of the Scottish National Prevalence Survey. Each objective set by the project initiation document and approved by the Project Steering Board and the HAITF has been met. Throughout the survey the budget remained within the tolerances set by the project team. Progress against the plan outlined in the Project Initiation Document (77) did not exceed the defined time and cost tolerances shown on Appendix Table 10-2 page 232.

The first exception to these plans was highlighted in the pilot report (4). The collection of International Classification of Disease (ICD-10) codes during the collection of LOS data proved not to be feasible. Many hospitals have a long backlog in coding patient notes according to the ICD-10 system. These delays were up to 6 months for some large teaching hospitals and due to the timescales of the project and the variable nature of the data available within the timescale of the project it was approved by the steering group that ICD-10 codes would not be collected for the survey.

The second exception was the investigation of the seasonal effect within the non-acute hospitals. Throughout the survey the seasonal distribution of the hospitals according to size and type was maintained. Within the non-acute hospitals this was not possible. This was communicated to the Steering Group and due to the limited variation in specialty within the non-acute hospitals it was agreed to maintain the plans within the acute hospitals at the expense of the non-acute hospitals seasonal planning. The recruitment of additional data collectors allowed the team to survey all the hospitals planned; however, the majority of non-acute hospitals were surveyed during the period May 2006 to July 2006. This may have affected the non-acute hospital univariate logistic regression analysis. Further work is required to investigate a possible seasonal effect on HAI prevalence in this setting.

8.8.2 Feasibility

Feasibility is defined as 'Whether something is able to be made, done or achieved'. The project has been completed within budget and on time according to the original Project Initiation Document presented to the HAITF. The project plans and the methodology enclosed in this document (Appendix 1 Protocol) were feasible and the aims and objectives outlined at the initiation phase of the project were achieved.

8.8.3 Cost

The funding received by HPS from the SEHD for the Scottish National Prevalence Survey was £577 885 (Table 7-1). This funding covered the development of the methodology, pilot survey, main survey, and production of the final report. The specific tasks undertaken were:

- Extensive review of HAI surveillance literature
- Development of data collection protocol
- Development of a data collection tool
- Production of publication materials
  - Posters
  - Staff Information leaflets
  - Patient Information leaflets
- Full pilot survey to test protocol, communications and data collection tool
- Communication with Hospitals and Stakeholder Groups before during and after the project
- Project Management of the Prevalence Survey
  - Monitoring cost and time
  - Monitoring Issues and Risks
  - Maintaining issues log and resolving issues relating to data collection
- Extensive training of data collectors in CDC Definitions and data collection tool
- One years travel and subsistence for each data collector when required
- Surveillance costs (salaries for staff)
- Multiple Validation studies throughout the survey
- Detailed analysis and production of final report
- Detailed analysis of individual hospital data and reporting to individual hospitals
- Communication with local staff throughout the project
- Consultancy costs for epidemiology, statistics and economics

The cost to the service has been estimated as £16 787 (Table 7-2). This covers the time spent by infection control and clinical staff in supporting the survey by undertaking the following tasks:

- Informing local clinical staff of the prevalence survey
- Arranging security clearance for the data collectors
- Providing the data collectors with orientation to the hospital
- Distributing posters and leaflets throughout the hospital
- Arranging presentations from the Project Manager when required
- Collecting and reporting LOS data for local medical records systems and returning them to HPS
- Introducing clinical staff to data collectors
- Providing brief orientation of ward set-up to data collectors
- Clinical staff answered any enquiries from data collectors
- Occasional chaperone in closed psychiatric wards

The original protocol (developed in early 2005) included a cost estimate for both the pilot and main survey of £564 896 (78). This cost comprised £61 948 for the pilot study and a further £502 948 for the main survey (Table 7-1). The pilot study undertaken in three acute hospitals allowed the team to accurately estimate the cost and time to survey a variety wards within the pilot hospitals. Some additional funds were required in order to allow the surveillance of a sample of non-acute hospitals.

By the conclusion of the project the total costs for the HPS project team were £577 885 with £532 885 being provided directly to the project by the Scottish Executive from the 'Clean Hospitals' budget awarded by the HAI Task Force. An additional £45 000 was provided during the development of the pilot protocol from NSS, which took the form of salaries for HPS staff involved in developing the initial protocol before the main survey team were recruited. Ninety seven percent of the costs and time effort were borne by the HPS team.

The hospitals varied in size but overall cost of staff time can be approximated using these data. The cost to the service has been calculated as £16 787. This corresponds to an average cost to local hospitals of £20 per ward surveyed. Each hospital will be provided with a detailed report on the Prevalence of HAI within their hospital and the project team believe this cost to have been acceptable. This is supported by the fact that the survey was undertaken and completed according to the initial plans.

Key Summary Point

- The methodology described in this report is both feasible and acceptable for prevalence surveillance in Scotland
- All nine objectives described at the initiation of the project have been addressed
- The central cost controlled by HPS were £577 885
- The cost the service was estimated to be £16 787
- The total cost of the prevalence Survey was £594 672

8.9 Objective 9 - What is a suitable methodology for repeated prevalence surveys, which give comparable information?

This survey has developed a standardised prevalence surveillance method allowing the collection of robust data for this survey. This can be used in the future for HAI surveillance at national and local levels. There are two key aspects to future prevalence surveillance. The first is surveillance of HAI at a national level. The second is to use prevalence surveillance to undertake smaller local investigations more frequently as part of local hospitals infection control programmes of work.

The Scottish national prevalence survey was a considerable undertaking for both HPS and the local NHS boards. It is unlikely that a survey on this scale would be undertaken on a frequent basis. The Prevalence Survey has been reviewed as part of the HPS evaluation of surveillance systems. This was undertaken by an expert panel of senior public health professionals and included input from a wide range of stakeholder representatives.

This review made two recommendations for the National HAI Prevalence Survey:

- A 10 year interval between repeat surveys is appropriate
- If repeated then a sample of hospitals is sufficient

The methodology and key principles for future prevalence surveillance should be considered applicable in 10 years time. It is probable that developments in electronic patient records systems may well make the undertaking of such a survey considerably simpler in future.

Using the results of this survey it may be possible to select a representative sample of hospitals which would provide an estimate of the prevalence of HAI in Scottish hospitals.

Whilst it is recommended that a national survey of HAI prevalence should not be undertaken more frequently than every 10 years, there is a possibility that repeated local prevalence surveillance could be used at a hospital or board level more frequently to investigate the effectiveness of interventions on the prevention of HAI. A proposal for future work that would allow local ICTs to undertake prevalence surveillance of their hospital or particular specialty as part of their regular programme of work with the support of HPS has been developed. This approach would have a number of advantages.

- There would be a number of personnel within the service developing the skills to undertake prevalence surveillance.
- Prevalence is a relatively cheap and rapid way of estimating all HAI in a hospital. A number of surveys would need to undertaken afterwards to ensure the estimate of the survey was statistically sound.
- There are a number of hospitals within Scotland that do not qualify to be included with-in the incidence programmes undertaken as part of the SSHAIP surveillance, either because they do not undertake sufficient numbers of procedures to qualify or they do not undertake the specific procedures. Prevalence surveillance at a local level would allow such hospitals to monitor their HAI trends at a relatively low cost.