國立雲林科技大學
九十二學年度研究所博士班招生考試試題

系所別：企業管理系
科　目：統計學

一、基本觀念題：(每題 4 分，共計 40 分)

1. 請舉一個隨機試驗(trial)實例，繪圖表示樣本空間(Samples Space)、隨機變數(Random Variable)與機率函數(Probability Function)三者之間結構性關係(Structure)。

2. 請簡要說明或圖示機率論(Probability)、抽樣論(Sampling Distribution)與統計方法(Statistical Method)三者間結構性關係。

3. 請簡要說明或圖示母數(Parameter) θ 、抽樣分配與統計量(Statistics) $\hat{\theta}$ 三者間結構性關係圖。

4. 請簡要說明機率分配(Probability Distribution)與次數分配(Frequency Distribution)之差異。

5. 請簡要說明期望值(Expectation)與平均數(Mean)之差異點。

6. 檢定假設 Ho：$\mu=\mu_0$ vs. H_1：$\mu \neq \mu_0$，請以 Critical Value Approach 與 P-Value Approach 方式，繪圖說明決策法則。

7. 假設母數 $\theta=\mu$，估計量 $\hat{\theta}=\overline{X}$，請簡要說明或圖示隨機區間(Random Interval)之意涵。

8. 在特定研究問題中，經常有假設命題，假設命題中之變數具有相依關係(Dependency)，假設變數衡量度(Measurement Scale)爲名目尺度(Nominal Scale)(以大寫英文字母 A 表示)與比率尺度(Ratio Scale)(以大寫英文字母 X 表示)；另變數又可分爲自變數(Independent)與反應變數(Dependent)兩種，請列出所有各種情況之函數關係或圖示之。

9. 請說明何以變異數分析(ANOVA)之檢定統計量爲 F 分配，且何以 ANOVA 一定爲右尾檢定。

10. 假設以下變數之衡量尺度爲比率尺度，其中 X_1，X_2 爲自變數，Y 爲反應變數，另假設 γ_{x1y}，γ_{X2Y} 具高度顯著線性相關，且 X_1 與 X_2 存在線性相關(γ_{X1X2})，請寫出所有相關迴歸方程式與圖示表示其間徑路(Path)關係。

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二、雲林縣政府爲發展華山特有品種台灣咖啡，進行咖啡消費者行爲研究，以咖啡飲用量爲反應變數，以消費者之職業與性別爲因子：(10 分)

1. 試寫出欲分析之各種函數關係。
2. 繪圖表示職業與性別交互反應效果，並說明意涵。
3. 繪圖表示職業與性別無交互反應效果，並說明意涵。
4. 設職業具有 3 個 Level(白領階層、藍領階層、學生階層)，性別有 2 個 Level(男性與女性)，請以 Excel 之工作表(Sheet)型式表示資料輸入型態，假設每組內皆有 5 個樣本。

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※注意：可攜帶僅具有計算功能之計算機

三、

1. 研究人員對濁水溪的魚類進行金屬含量研究，採隨機抽樣，找到 10 個含銅樣本及 8 個含鉛樣本，S_1 及 S_2 分別爲這兩組金屬含量樣本的標準差，假設銅含量的母體變異數兩倍鉛含量的母體變異數，且兩樣本變異數互相獨立，試求 a、b 使得 $P(a \le \frac{S_1^2}{S_2^2} \le b) = 0.90$。(10%)

2. 設 Y 爲 n=25 且 P=0.4 之二項分配，試比較 $Y \le 8$ 與 $Y = 8$ 的真實機率與常態近似值。(12%)

3. 農業專家以 PH 值衡量土壤的酸鹼性，PH 值範圍從 0(強酸)到 14(強鹼)，他現在要估計一大塊農地的平均 PH 值，雖然這塊地 PH 值的母體標準差未知，但由過去檢測經驗，他知道大部份的土壤 PH 值介於 5 到 8 之間。(1)如果他隨機抽出 40 份土壤樣本，試求這些樣本平均 PH 值與真實母體平均 PH 值相差 0.2 以內的近似機率(5%)？(2)另外，若要讓樣本平均 PH 值與真實母體平均 PH 值相差 0.1 以內的機率爲 90%，則應抽多少個樣本呢？(3%)

4. 已知某國家有 5%的人染患 B 型肝炎，發病前的患者因不知自己會散播病毒，很容易將 B 型肝炎傳染給他人；所以，醫師都希望能事先篩檢出 B 型肝炎患者，以減少該病擴散。現在，該國政府想要進行大規模 B 型肝炎篩檢，但全國人口(N)非常多，在考慮經費與篩檢效果的條件下，公共衛生專家擬訂了兩種篩檢方式：(A)對全國每個人都檢查；或(B)以 k 個人爲一組，故 $N=nk$(n 爲整數)，將每組 k 個人的檢體混合在一起，先做一次檢驗，若檢驗結果爲陰性反應，則認爲這 k 個人都沒有感染 B 型肝炎，就不再逐一檢查這 k 個人，若整組檢驗結果爲陽性反應，則再對此 k 個人逐一檢查。請您回答以下問題：(1)若 k 固定，求採用(B)法所需的期望檢查次數(8%)；(2)試求採用(B)法時，使期望檢查次數最少的 k 值(10%)；(3)請問(B)篩檢法比(A)篩檢法最多減少幾次檢查次數？(2%)

表 1　二項分配函數

n	c	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
n=1	0	.950	.900	.800	.700	.600	.500	.400	.300	.200	.100	.050
	1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=2	0	.902	.810	.640	.490	.360	.250	.160	.090	.040	.010	.002
	1	.997	.990	.960	.910	.840	.750	.640	.510	.360	.190	.097
	2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=3	0	.857	.729	.512	.343	.216	.125	.064	.027	.008	.001	.000
	1	.993	.972	.896	.784	.648	.500	.352	.216	.104	.028	.007
	2	1.000	.999	.992	.973	.936	.875	.784	.657	.488	.271	.143
	3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=4	0	.815	.656	.410	.240	.130	.063	.026	.008	.002	.000	.000
	1	.986	.948	.819	.652	.475	.313	.179	.084	.027	.004	.000
	2	1.000	.996	.973	.916	.821	.688	.525	.348	.181	.052	.014
	3	1.000	1.000	.998	.992	.974	.938	.870	.760	.590	.344	.185
	4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=5	0	.774	.590	.328	.168	.078	.031	.010	.002	.000	.000	.000
	1	.977	.919	.737	.528	.337	.188	.087	.031	.007	.000	.000
	2	.999	.991	.942	.837	.683	.500	.317	.163	.058	.009	.001
	3	1.000	1.000	.993	.969	.913	.813	.663	.472	.263	.081	.023
	4	1.000	1.000	1.000	.998	.990	.969	.922	.832	.672	.410	.226
	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=6	0	.735	.531	.262	.118	.047	.016	.004	.001	.000	.000	.000
	1	.967	.886	.655	.420	.233	.109	.041	.011	.002	.000	.000
	2	.998	.984	.901	.744	.544	.344	.179	.070	.017	.001	.000
	3	1.000	.999	.983	.930	.821	.656	.456	.256	.099	.016	.002
	4	1.000	1.000	.998	.989	.959	.891	.767	.580	.345	.114	.033
	5	1.000	1.000	1.000	.999	.996	.984	.953	.882	.738	.469	.265
	6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=7	0	.698	.478	.210	.082	.028	.008	.002	.000	.000	.000	.000
	1	.956	.850	.577	.329	.159	.063	.019	.004	.000	.000	.000
	2	.996	.974	.852	.647	.420	.227	.096	.029	.005	.000	.000
	3	1.000	.997	.967	.874	.710	.500	.290	.126	.033	.003	.000
	4	1.000	1.000	.995	.971	.904	.773	.580	.353	.148	.026	.004
	5	1.000	1.000	1.000	.996	.981	.938	.841	.671	.423	.150	.044
	6	1.000	1.000	1.000	1.000	.998	.992	.972	.918	.790	.522	.302
	7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=8	0	.663	.430	.168	.058	.017	.004	.001	.000	.000	.000	.000
	1	.943	.813	.503	.255	.106	.035	.009	.001	.000	.000	.000
	2	.994	.962	.797	.552	.315	.145	.050	.011	.001	.000	.000
	3	1.000	.995	.944	.806	.594	.363	.174	.058	.010	.000	.000
	4	1.000	1.000	.990	.942	.826	.637	.406	.194	.056	.005	.000
	5	1.000	1.000	.999	.989	.950	.855	.685	.448	.203	.038	.006
	6	1.000	1.000	1.000	.999	.991	.965	.894	.745	.497	.187	.057
	7	1.000	1.000	1.000	1.000	.999	.996	.983	.942	.832	.570	.337
	8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=9	0	.630	.387	.134	.040	.010	.002	.000	.000	.000	.000	.000
	1	.929	.775	.436	.196	.071	.020	.004	.000	.000	.000	.000
	2	.992	.947	.738	.463	.232	.090	.025	.004	.000	.000	.000
	3	.999	.992	.914	.730	.483	.254	.099	.025	.003	.000	.000
	4	1.000	.999	.980	.901	.733	.500	.267	.099	.020	.001	.000
	5	1.000	1.000	.997	.975	.901	.746	.517	.270	.086	.008	.001
	6	1.000	1.000	1.000	.996	.975	.910	.768	.537	.262	.053	.008
	7	1.000	1.000	1.000	1.000	.996	.980	.929	.804	.564	.225	.071
	8	1.000	1.000	1.000	1.000	1.000	.998	.990	.960	.866	.613	.370
	9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=10	0	.599	.349	.107	.028	.006	.001	.000	.000	.000	.000	.000
	1	.914	.736	.376	.149	.046	.011	.002	.000	.000	.000	.000
	2	.988	.930	.678	.383	.167	.055	.012	.002	.000	.000	.000
	3	.999	.987	.879	.650	.382	.172	.055	.011	.001	.000	.000
	4	1.000	.998	.967	.850	.633	.377	.166	.047	.006	.000	.000
	5	1.000	1.000	.994	.953	.834	.623	.367	.150	.033	.002	.000
	6	1.000	1.000	.999	.989	.945	.828	.618	.350	.121	.013	.001
	7	1.000	1.000	1.000	.998	.988	.945	.833	.617	.322	.070	.012
	8	1.000	1.000	1.000	1.000	.998	.989	.954	.851	.624	.264	.086
	9	1.000	1.000	1.000	1.000	1.000	.999	.994	.972	.893	.651	.401
	10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n=11	0	.569	.314	.086	.020	.004	.000	.000	.000	.000	.000	.000
	1	.898	.697	.322	.113	.030	.006	.001	.000	.000	.000	.000
	2	.985	.910	.617	.313	.119	.033	.006	.001	.000	.000	.000
	3	.998	.981	.839	.570	.296	.113	.029	.004	.000	.000	.000

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表 1　二項分配函數（續）

n	c	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
	4	1.000	.997	.950	.790	.533	.274	.099	.022	.002	.000	.000
	5	1.000	1.000	.988	.922	.753	.500	.247	.078	.012	.000	.000
	6	1.000	1.000	.998	.978	.901	.726	.467	.210	.050	.003	.000
	7	1.000	1.000	1.000	.996	.971	.887	.704	.430	.161	.019	.002
	8	1.000	1.000	1.000	.999	.994	.967	.881	.687	.383	.090	.015
	9	1.000	1.000	1.000	1.000	.999	.994	.970	.887	.678	.303	.102
	10	1.000	1.000	1.000	1.000	1.000	1.000	.996	.980	.914	.686	.431
	11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 12	0	.540	.282	.069	.014	.002	.000	.000	.000	.000	.000	.000
	1	.882	.659	.275	.085	.020	.003	.000	.000	.000	.000	.000
	2	.980	.889	.558	.253	.083	.019	.003	.000	.000	.000	.000
	3	.998	.974	.795	.493	.225	.073	.015	.002	.000	.000	.000
	4	1.000	.996	.927	.724	.438	.194	.057	.009	.001	.000	.000
	5	1.000	.999	.981	.882	.665	.387	.158	.039	.004	.000	.000
	6	1.000	1.000	.996	.961	.842	.613	.335	.118	.019	.001	.000
	7	1.000	1.000	.999	.991	.943	.806	.562	.276	.073	.004	.000
	8	1.000	1.000	1.000	.998	.985	.927	.775	.507	.205	.026	.002
	9	1.000	1.000	1.000	1.000	.997	.981	.917	.747	.442	.111	.020
	10	1.000	1.000	1.000	1.000	1.000	.997	.980	.915	.725	.341	.118
	11	1.000	1.000	1.000	1.000	1.000	1.000	.998	.986	.931	.718	.460
	12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 13	0	.513	.254	.055	.010	.001	.000	.000	.000	.000	.000	.000
	1	.865	.621	.234	.064	.013	.002	.000	.000	.000	.000	.000
	2	.975	.866	.502	.202	.058	.011	.001	.000	.000	.000	.000
	3	.997	.966	.747	.421	.169	.046	.008	.001	.000	.000	.000
	4	1.000	.994	.901	.654	.353	.133	.032	.004	.000	.000	.000
	5	1.000	.999	.970	.835	.574	.291	.098	.018	.001	.000	.000
	6	1.000	1.000	.993	.938	.771	.500	.229	.062	.007	.000	.000
	7	1.000	1.000	.999	.982	.902	.709	.426	.165	.030	.001	.000
	8	1.000	1.000	1.000	.996	.968	.867	.647	.346	.099	.006	.000
	9	1.000	1.000	1.000	.999	.992	.954	.831	.579	.253	.034	.003
	10	1.000	1.000	1.000	1.000	.999	.989	.942	.798	.498	.134	.025
	11	1.000	1.000	1.000	1.000	1.000	.998	.987	.936	.766	.379	.135
	12	1.000	1.000	1.000	1.000	1.000	1.000	.999	.990	.945	.746	.487
	13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 14	0	.488	.229	.044	.007	.001	.000	.000	.000	.000	.000	.000
	1	.847	.585	.198	.047	.008	.001	.000	.000	.000	.000	.000
	2	.970	.842	.448	.161	.040	.006	.001	.000	.000	.000	.000
	3	.996	.956	.698	.355	.124	.029	.004	.000	.000	.000	.000
	4	1.000	.991	.870	.584	.279	.090	.018	.002	.000	.000	.000
	5	1.000	.999	.956	.781	.486	.212	.058	.008	.000	.000	.000
	6	1.000	1.000	.988	.907	.692	.395	.150	.031	.002	.000	.000
	7	1.000	1.000	.998	.969	.850	.605	.308	.093	.012	.000	.000
	8	1.000	1.000	1.000	.992	.942	.788	.514	.219	.044	.001	.000
	9	1.000	1.000	1.000	.998	.982	.910	.721	.416	.130	.009	.000
	10	1.000	1.000	1.000	1.000	.996	.971	.876	.645	.302	.044	.004
	11	1.000	1.000	1.000	1.000	.999	.994	.960	.839	.552	.158	.030
	12	1.000	1.000	1.000	1.000	1.000	.999	.992	.953	.802	.415	.153
	13	1.000	1.000	1.000	1.000	1.000	1.000	.999	.993	.956	.771	.512
	14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 15	0	.463	.206	.035	.005	.000	.000	.000	.000	.000	.000	.000
	1	.829	.549	.167	.035	.005	.000	.000	.000	.000	.000	.000
	2	.964	.816	.398	.127	.027	.004	.000	.000	.000	.000	.000
	3	.995	.944	.648	.297	.091	.018	.002	.000	.000	.000	.000
	4	.999	.987	.836	.515	.217	.059	.009	.001	.000	.000	.000
	5	1.000	.998	.939	.722	.403	.151	.034	.004	.000	.000	.000
	6	1.000	1.000	.982	.869	.610	.304	.095	.015	.001	.000	.000
	7	1.000	1.000	.996	.950	.787	.500	.213	.050	.004	.000	.000
	8	1.000	1.000	.999	.985	.905	.696	.390	.131	.018	.000	.000
	9	1.000	1.000	1.000	.996	.966	.849	.597	.278	.061	.002	.000
	10	1.000	1.000	1.000	.999	.991	.941	.783	.485	.164	.013	.001
	11	1.000	1.000	1.000	1.000	.998	.982	.909	.703	.352	.056	.005
	12	1.000	1.000	1.000	1.000	1.000	.996	.973	.873	.602	.184	.036
	13	1.000	1.000	1.000	1.000	1.000	1.000	.995	.965	.833	.451	.171
	14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.995	.965	.794	.537
	15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 16	0	.440	.185	.028	.003	.000	.000	.000	.000	.000	.000	.000
	1	.811	.515	.141	.026	.003	.000	.000	.000	.000	.000	.000
	2	.957	.789	.352	.099	.018	.002	.000	.000	.000	.000	.000
	3	.993	.932	.598	.246	.065	.011	.001	.000	.000	.000	.000
	4	.999	.983	.798	.450	.167	.038	.005	.000	.000	.000	.000
	5	1.000	.997	.918	.660	.329	.105	.019	.002	.000	.000	.000
	6	1.000	.999	.973	.825	.527	.227	.058	.007	.000	.000	.000
	7	1.000	1.000	.993	.926	.716	.402	.142	.026	.001	.000	.000
	8	1.000	1.000	.999	.974	.858	.598	.284	.074	.007	.000	.000
	9	1.000	1.000	1.000	.993	.942	.773	.473	.175	.027	.001	.000
	10	1.000	1.000	1.000	.998	.981	.895	.671	.340	.082	.003	.000

國立雲林科技大學
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系所別：企業管理系
科　目：統計學

表1　二項分配函數（續）

n	c	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
	11	1.000	1.000	1.000	1.000	.995	.962	.833	.550	.202	.017	.001
	12	1.000	1.000	1.000	1.000	.999	.989	.935	.754	.402	.068	.007
	13	1.000	1.000	1.000	1.000	1.000	.998	.982	.901	.648	.211	.043
	14	1.000	1.000	1.000	1.000	1.000	1.000	.997	.974	.859	.485	.189
	15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.997	.972	.815	.560
	16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 17	0	.418	.167	.023	.002	.000	.000	.000	.000	.000	.000	.000
	1	.792	.482	.118	.019	.002	.000	.000	.000	.000	.000	.000
	2	.950	.762	.310	.077	.012	.001	.000	.000	.000	.000	.000
	3	.991	.917	.549	.202	.046	.006	.000	.000	.000	.000	.000
	4	.999	.978	.758	.389	.126	.025	.003	.000	.000	.000	.000
	5	1.000	.995	.894	.597	.264	.072	.011	.001	.000	.000	.000
	6	1.000	.999	.962	.775	.448	.166	.035	.003	.000	.000	.000
	7	1.000	1.000	.989	.895	.641	.315	.092	.013	.000	.000	.000
	8	1.000	1.000	.997	.960	.801	.500	.199	.040	.003	.000	.000
	9	1.000	1.000	1.000	.987	.908	.685	.359	.105	.011	.000	.000
	10	1.000	1.000	1.000	.997	.965	.834	.552	.225	.038	.001	.000
	11	1.000	1.000	1.000	.999	.989	.928	.736	.403	.106	.005	.000
	12	1.000	1.000	1.000	1.000	.997	.975	.874	.611	.242	.022	.001
	13	1.000	1.000	1.000	1.000	1.000	.994	.954	.798	.451	.083	.009
	14	1.000	1.000	1.000	1.000	1.000	.999	.988	.923	.690	.238	.050
	15	1.000	1.000	1.000	1.000	1.000	1.000	.998	.981	.882	.518	.208
	16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	.977	.833	.582
	17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 18	0	.397	.150	.018	.002	.000	.000	.000	.000	.000	.000	.000
	1	.774	.450	.099	.014	.001	.000	.000	.000	.000	.000	.000
	2	.942	.734	.271	.060	.008	.001	.000	.000	.000	.000	.000
	3	.989	.902	.501	.165	.033	.004	.000	.000	.000	.000	.000
	4	.998	.972	.716	.333	.094	.015	.001	.000	.000	.000	.000
	5	1.000	.994	.867	.534	.209	.048	.006	.000	.000	.000	.000
	6	1.000	.999	.949	.722	.374	.119	.020	.001	.000	.000	.000
	7	1.000	1.000	.984	.859	.563	.240	.058	.006	.000	.000	.000
	8	1.000	1.000	.996	.940	.737	.407	.135	.021	.001	.000	.000
	9	1.000	1.000	.999	.979	.865	.593	.263	.060	.004	.000	.000
	10	1.000	1.000	1.000	.994	.942	.760	.437	.141	.016	.000	.000
	11	1.000	1.000	1.000	.999	.980	.881	.626	.278	.051	.001	.000
	12	1.000	1.000	1.000	1.000	.994	.952	.791	.466	.133	.006	.000
	13	1.000	1.000	1.000	1.000	.999	.985	.906	.667	.284	.028	.002
	14	1.000	1.000	1.000	1.000	1.000	.996	.967	.835	.499	.098	.011

n	c	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
	15	1.000	1.000	1.000	1.000	1.000	.999	.992	.940	.729	.266	.058
	16	1.000	1.000	1.000	1.000	1.000	1.000	.999	.986	.901	.550	.226
	17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	.982	.850	.603
	18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 19	0	.377	.135	.014	.001	.000	.000	.000	.000	.000	.000	.000
	1	.755	.420	.083	.010	.001	.000	.000	.000	.000	.000	.000
	2	.933	.705	.237	.046	.005	.000	.000	.000	.000	.000	.000
	3	.987	.885	.455	.133	.023	.002	.000	.000	.000	.000	.000
	4	.998	.965	.673	.282	.070	.010	.001	.000	.000	.000	.000
	5	1.000	.991	.837	.474	.163	.032	.003	.000	.000	.000	.000
	6	1.000	.998	.932	.666	.308	.084	.012	.001	.000	.000	.000
	7	1.000	1.000	.977	.818	.488	.180	.035	.003	.000	.000	.000
	8	1.000	1.000	.993	.916	.667	.324	.088	.011	.000	.000	.000
	9	1.000	1.000	.998	.967	.814	.500	.186	.033	.002	.000	.000
	10	1.000	1.000	1.000	.989	.912	.676	.333	.084	.007	.000	.000
	11	1.000	1.000	1.000	.997	.965	.820	.512	.182	.023	.000	.000
	12	1.000	1.000	1.000	.999	.988	.916	.692	.334	.068	.002	.000
	13	1.000	1.000	1.000	1.000	.997	.968	.837	.526	.163	.009	.000
	14	1.000	1.000	1.000	1.000	.999	.990	.930	.718	.327	.035	.002
	15	1.000	1.000	1.000	1.000	1.000	.998	.977	.867	.545	.115	.013
	16	1.000	1.000	1.000	1.000	1.000	1.000	.995	.954	.763	.295	.067
	17	1.000	1.000	1.000	1.000	1.000	1.000	.999	.990	.917	.580	.245
	18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	.986	.865	.623
	19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
n = 20	0	.358	.122	.012	.001	.000	.000	.000	.000	.000	.000	.000
	1	.736	.392	.069	.008	.001	.000	.000	.000	.000	.000	.000
	2	.925	.677	.206	.035	.004	.000	.000	.000	.000	.000	.000
	3	.984	.867	.411	.107	.016	.001	.000	.000	.000	.000	.000
	4	.997	.957	.630	.238	.051	.006	.000	.000	.000	.000	.000
	5	1.000	.989	.804	.416	.126	.021	.002	.000	.000	.000	.000
	6	1.000	.998	.913	.608	.250	.058	.006	.000	.000	.000	.000
	7	1.000	1.000	.968	.772	.416	.132	.021	.001	.000	.000	.000
	8	1.000	1.000	.990	.887	.596	.252	.057	.005	.000	.000	.000
	9	1.000	1.000	.997	.952	.755	.412	.128	.017	.001	.000	.000
	10	1.000	1.000	.999	.983	.872	.588	.245	.048	.003	.000	.000
	11	1.000	1.000	1.000	.995	.943	.748	.404	.113	.010	.000	.000
	12	1.000	1.000	1.000	.999	.979	.868	.584	.228	.032	.000	.000
	13	1.000	1.000	1.000	1.000	.994	.942	.750	.392	.087	.002	.000
	14	1.000	1.000	1.000	1.000	.998	.979	.874	.584	.196	.011	.000

表 1　二項分配函數（續）

n	c	p = .05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
	15	1.000	1.000	1.000	1.000	1.000	.994	.949	.762	.370	.043	.003
	16	1.000	1.000	1.000	1.000	1.000	.999	.984	.893	.589	.133	.016
	17	1.000	1.000	1.000	1.000	1.000	1.000	.996	.965	.794	.323	.075
	18	1.000	1.000	1.000	1.000	1.000	1.000	.999	.992	.931	.608	.264
	19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	.988	.878	.642
	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
$n=25$	0	.277	.072	.004	.000	.000	.000	.000	.000	.000	.000	.000
	1	.642	.271	.027*	.002	.000	.000	.000	.000	.000	.000	.000
	2	.873	.537	.098	.009	.000	.000	.000	.000	.000	.000	.000
	3	.966	.764	.234	.033	.002	.000	.000	.000	.000	.000	.000
	4	.993	.902	.421	.090	.009	.000	.000	.000	.000	.000	.000
	5	.999	.967	.617	.193	.029	.002	.000	.000	.000	.000	.000
	6	1.000	.991	.780	.341	.074	.007	.000	.000	.000	.000	.000
	7	1.000	.998	.891	.512	.154	.022	.001	.000	.000	.000	.000
	8	1.000	1.000	.953	.677	.274	.054	.004	.000	.000	.000	.000
	9	1.000	1.000	.983	.811	.425	.115	.013	.000	.000	.000	.000
	10	1.000	1.000	.994	.902	.586	.212	.034	.002	.000	.000	.000
	11	1.000	1.000	.998	.956	.732	.345	.078	.006	.000	.000	.000
	12	1.000	1.000	1.000	.983	.846	.500	.154	.017	.000	.000	.000
	13	1.000	1.000	1.000	.994	.922	.655	.268	.044	.002	.000	.000
	14	1.000	1.000	1.000	.998	.966	.788	.414	.098	.006	.000	.000
	15	1.000	1.000	1.000	1.000	.987	.885	.575	.189	.017	.000	.000
	16	1.000	1.000	1.000	1.000	.996	.946	.726	.323	.047	.000	.000
	17	1.000	1.000	1.000	1.000	.999	.978	.846	.488	.109	.002	.000
	18	1.000	1.000	1.000	1.000	1.000	.993	.926	.659	.220	.009	.000
	19	1.000	1.000	1.000	1.000	1.000	.998	.971	.807	.383	.033	.001
	20	1.000	1.000	1.000	1.000	1.000	1.000	.991	.910	.579	.098	.007
	21	1.000	1.000	1.000	1.000	1.000	1.000	.998	.967	.766	.236	.034
	22	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.991	.902	.463	.127
	23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	.973	.729	.358
	24	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.996	.928	.723
	25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

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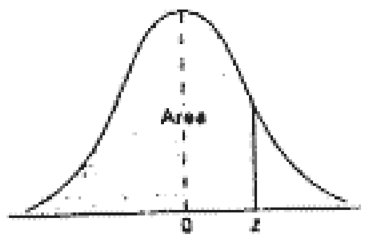

Table A.3 (continued) Areas Under the Normal Curve

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9278	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

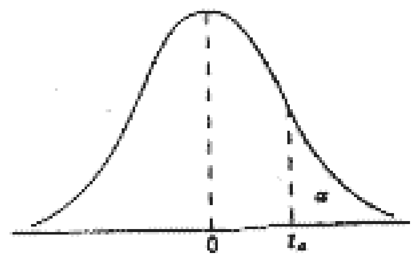

Table A.4 Critical Values of the t-Distribution

v	α						
	0.40	0.30	0.20	0.15	0.10	0.05	0.025
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228
11	0.260	0.540	0.876	1.088	1.363	1.796	2.201
12	0.259	0.539	0.873	1.083	1.356	1.782	2.179
13	0.259	0.537	0.870	1.079	1.350	1.771	2.160
14	0.258	0.537	0.868	1.076	1.345	1.761	2.145
15	0.258	0.536	0.866	1.074	1.341	1.753	2.131
16	0.258	0.535	0.865	1.071	1.337	1.746	2.120
17	0.257	0.534	0.863	1.069	1.333	1.740	2.110
18	0.257	0.534	0.862	1.067	1.330	1.734	2.101
19	0.257	0.533	0.861	1.066	1.328	1.729	2.093
20	0.257	0.533	0.860	1.064	1.325	1.725	2.086
21	0.257	0.532	0.859	1.063	1.323	1.721	2.080
22	0.256	0.532	0.858	1.061	1.321	1.717	2.074
23	0.256	0.532	0.858	1.060	1.319	1.714	2.069
24	0.256	0.531	0.857	1.059	1.318	1.711	2.064
25	0.256	0.531	0.856	1.058	1.316	1.708	2.060
26	0.256	0.531	0.856	1.058	1.315	1.706	2.056
27	0.256	0.531	0.855	1.057	1.314	1.703	2.052
28	0.256	0.530	0.855	1.056	1.313	1.701	2.048
29	0.256	0.530	0.854	1.055	1.311	1.699	2.045
30	0.256	0.530	0.854	1.055	1.310	1.697	2.042
40	0.255	0.529	0.851	1.050	1.303	1.684	2.021
60	0.254	0.527	0.848	1.045	1.296	1.671	2.000
120	0.254	0.526	0.845	1.041	1.289	1.658	1.980
∞	0.253	0.524	0.842	1.036	1.282	1.645	1.960

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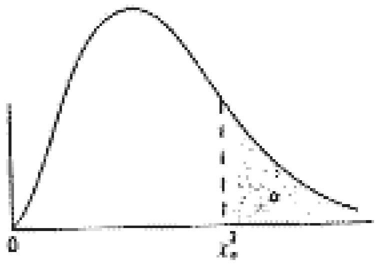

Table A.5 Critical Values of the Chi-Squared Distribution

v	α = 0.995	0.99	0.98	0.975	0.95	0.90	0.80	0.75	0.75	0.50
1	0.0^4393	0.0^3157	0.0^3628	0.0^3982	0.00393	0.0158	0.0642	0.102	0.148	0.455
2	0.0100	0.0201	0.0404	0.0506	0.103	0.211	0.446	0.575	0.713	1.386
3	0.0717	0.115	0.185	0.216	0.352	0.584	1.005	1.213	1.424	2.366
4	0.207	0.297	0.429	0.484	0.711	1.064	1.649	1.923	2.195	3.357
5	0.412	0.554	0.752	0.831	1.145	1.610	2.343	2.675	3.000	4.351
6	0.676	0.872	1.134	1.237	1.635	2.204	3.070	3.455	3.828	5.348
7	0.989	1.239	1.564	1.690	2.167	2.833	3.822	4.255	4.671	6.346
8	1.344	1.646	2.032	2.180	2.733	3.490	4.594	5.071	5.527	7.344
9	1.735	2.088	2.532	2.700	3.325	4.168	5.380	5.899	6.393	8.343
10	2.156	2.558	3.059	3.247	3.940	4.865	6.179	6.737	7.267	9.342
11	2.603	3.053	3.609	3.816	4.575	5.578	6.989	7.584	8.148	10.341
12	3.074	3.571	4.178	4.404	5.226	6.304	7.807	8.438	9.034	11.340
13	3.565	4.107	4.765	5.009	5.892	7.042	8.634	9.299	9.926	12.340
14	4.075	4.660	5.368	5.629	6.571	7.790	9.467	10.165	10.821	13.339
15	4.601	5.229	5.985	6.262	7.261	8.547	10.307	11.036	11.721	14.339
16	5.142	5.812	6.614	6.908	7.962	9.312	11.152	11.912	12.624	15.338
17	5.697	6.408	7.255	7.564	8.672	10.085	12.002	12.792	13.531	16.338
18	6.265	7.015	7.906	8.231	9.390	10.865	12.857	13.675	14.440	17.338
19	6.844	7.633	8.567	8.907	10.117	11.651	13.716	14.562	15.352	18.338
20	7.434	8.260	9.237	9.591	10.851	12.443	14.578	15.452	16.266	19.337
21	8.034	8.897	9.915	10.283	11.591	13.240	15.445	16.344	17.182	20.337
22	8.643	9.542	10.600	10.982	12.338	14.041	16.314	17.240	18.101	21.337
23	9.260	10.196	11.293	11.688	13.091	14.848	17.187	18.137	19.021	22.337
24	9.886	10.856	11.992	12.401	13.848	15.659	18.062	19.037	19.943	23.337
25	10.520	11.524	12.697	13.120	14.611	16.473	18.940	19.939	20.867	24.337
26	11.160	12.198	13.409	13.844	15.379	17.292	19.820	20.843	21.792	25.336
27	11.808	12.879	14.125	14.573	16.151	18.114	20.703	21.749	22.719	26.336
28	12.461	13.565	14.847	15.308	16.928	18.939	21.588	22.657	23.647	27.336
29	13.121	14.256	15.574	16.047	17.708	19.768	22.475	23.567	24.577	28.336
30	13.787	14.953	16.306	16.791	18.493	20.599	23.364	24.478	25.508	29.336

Table A.5 (continued) Critical Values of the Chi-Squared Distribution

v	α = 0.30	0.25	0.20	0.10	0.05	0.025	0.02	0.01	0.005	0.001
1	1.074	1.323	1.642	2.706	3.841	5.024	5.412	6.635	7.879	10.827
2	2.408	2.773	3.219	4.605	5.991	7.378	7.824	9.210	10.597	13.815
3	3.665	4.108	4.642	6.251	7.815	9.348	9.837	11.345	12.838	16.268
4	4.878	5.385	5.989	7.779	9.488	11.143	11.668	13.277	14.860	18.465
5	6.064	6.626	7.289	9.236	11.070	12.832	13.388	15.086	16.750	20.517
6	7.231	7.841	8.558	10.645	12.592	14.449	15.033	16.812	18.548	22.457
7	8.383	9.037	9.803	12.017	14.067	16.013	16.622	18.475	20.278	24.322
8	9.524	10.219	11.030	13.362	15.507	17.535	18.168	20.090	21.955	26.125
9	10.656	11.389	12.242	14.684	16.919	19.023	19.679	21.666	23.589	27.877
10	11.781	12.549	13.442	15.987	18.307	20.483	21.161	23.209	25.188	29.588
11	12.899	13.701	14.631	17.275	19.675	21.920	22.618	24.725	26.757	31.264
12	14.011	14.845	15.812	18.549	21.026	23.337	24.054	26.217	28.300	32.909
13	15.119	15.984	16.985	19.812	22.362	24.736	25.472	27.688	29.819	34.528
14	16.222	17.117	18.151	21.064	23.685	26.119	26.873	29.141	31.319	36.123
15	17.322	18.245	19.311	22.307	24.996	27.488	28.259	30.578	32.801	37.697
16	18.418	19.369	20.465	23.542	26.296	28.845	29.633	32.000	34.267	39.252
17	19.511	20.489	21.615	24.769	27.587	30.191	30.995	33.409	35.718	40.790
18	20.601	21.605	22.760	25.989	28.869	31.526	32.346	34.805	37.156	42.312
19	21.689	22.718	23.900	27.204	30.144	32.852	33.687	36.191	38.582	43.820
20	22.775	23.828	25.038	28.412	31.410	34.170	35.020	37.566	39.997	45.315
21	23.858	24.935	26.171	29.615	32.671	35.479	36.343	38.932	41.401	46.797
22	24.939	26.039	27.301	30.813	33.924	36.781	37.659	40.289	42.796	48.268
23	26.018	27.141	28.429	32.007	35.172	38.076	38.968	41.638	44.181	49.728
24	27.096	28.241	29.553	33.196	36.415	39.364	40.270	42.980	45.558	51.179
25	28.172	29.339	30.675	34.382	37.652	40.646	41.566	44.314	46.928	52.620
26	29.246	30.434	31.795	35.563	38.885	41.923	42.856	45.642	48.290	54.052
27	30.319	31.528	32.912	36.741	40.113	43.194	44.140	46.963	49.645	55.476
28	31.391	32.620	34.027	37.916	41.337	44.461	45.419	48.278	50.993	56.893
29	32.461	33.711	35.139	39.087	42.557	45.722	46.693	49.588	52.336	58.302
30	33.530	34.800	36.250	40.256	43.773	46.979	47.962	50.892	53.672	59.703

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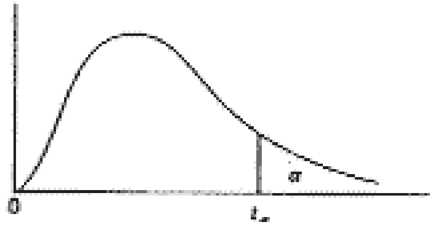

Table A.6* *Critical Values of the F-Distribution*

$f_{0.05}(v_1, v_2)$

v_2 \ v_1	1	2	3	4	5	6	7	8	9
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88

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Table A.6 *(continued)* *Critical Values of the F-Distribution*

$f_{0.05}(v_1, v_2)$

v_2 \ v_1	10	12	15	20	24	30	40	60	120	∞
1	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3
2	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

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請詳細閱讀完本文，並根據本文之意函，回答以下問題：

1.

從本文的研究動機，探討問題等方面的說明，作者認為醫療組織傳統上解決問題，提供服務的工作依據？本文希能對該工作依據提出何種改變?又希望建立何種新工作依據的管理方式。

（20% ）

2. 本文所探討的對象：『First-order problem solving』及『Second-order problem solving』，請系統性的比較說明，醫護人員對此兩類問題的解決方式差異；包括：問題性質、醫護解決問題方法、資訊依據、組織內部的互動，對服務績效的影響等。

（30% ）

3. 承上題，並請依據圖一（figure 1）歸納作者所謂之 dynamics of Process Failures？分析時須將 organizational 與 psychological 所分別促成之 illusory equilibrium 的動態（dynamic）成因，予以系統的描述。

（50% ）

（為求評分公正性，除專有名詞外，請一律以中文作答）

承文開始.

①

Why Hospitals Don't Learn from Failures:

Organizational and Psychological Dynamics that Inhibit System Change

Anita L. Tucker
Amy C. Edmondson

The importance of hospitals learning from their failures hardly needs to be stated. Not only are matters of life and death at stake on a daily basis, but also an increasing number of U.S. hospitals are operating in the red.[1] Organizational learning is thus an imperative. Recent research suggests there are plenty of problems, errors, and other learning opportunities facing these complex service organizations. In 2000, the Institute of Medicine issued a report estimating that 44,000 to 98,000 people die each year as a result of medical errors.[2] Other studies suggest, in addition, that medical errors with less serious consequences are pervasive in hospitals.[3]

Hospitals historically have relied on a dedicated and highly skilled professional workforce to compensate for any operational failures that might occur during the patient care delivery process. Great doctors and nurses, not great organization or management, have been seen as the means for ensuring that patients receive quality care. Recently, however, the medical community has responded to increased public awareness of shortcomings in health care delivery by calling for systematic, organizational improvements to increase patient safety. Examples of such initiatives include creating shared databases of medical errors to facilitate widespread learning from mistakes and focusing renewed attention on hospital processes, culture, and reporting systems.[4]

Front-line employees in service organizations are well positioned in these efforts to help their organizations learn, that is, to improve organizational

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(2)

outcomes by suggesting changes in processes and activities based on their knowledge of what is and is not working.[5] Identifying and resolving causes of problems that arise during the course of work is one method for achieving organizational learning. By catching, correcting, and removing underlying causes, front-line employees can contribute to changes that help avoid erosion of quality and customer satisfaction in the future. In this way, through initiative taking and problem solving at the front lines, organizational systems and procedures can be changed to avoid many of the most prevalent recurring problems (sometimes referred to—perhaps overly optimistically—as "low hanging fruit").

We conducted a detailed study of hospital nursing care processes to investigate conditions under which nurses might respond to failures they encounter in their hospital's operational processes by actively seeking to prevent future occurrences of similar failures. Our research suggests that, in spite of increased emphasis on these issues, hospitals are not learning from the daily problems and errors encountered by their workers. We also find that process failures are not rare but rather are an integral part of working on the front lines of health care delivery.

Although this study focused on hospital nurses, the lessons learned have implications for managers in other service organizations as well. The tasks carried out by nurses are knowledge-intensive, highly variable, and performed in the physical presence of customers, which heightens the worker's focus on the current customer's comfort and safety and can detract from awareness of the need to improve the organizational system through which care is delivered. These aspects are similar to work environments of other service providers who perform complex physical and mental tasks in the presence of customers, such as computer help-desk operators, repair technicians, airline crews, fire fighters, police officers, teachers, beauticians, and some customer service representatives. Further, hospitals have many features in common with other service organizations, notably time pressure, unpredictability in the workload, the relatively low status of nurses as front-line employees, and their reliance on others for supplies and information. These features contribute both to the emergence of failures and to barriers to learning from them.

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Process Failures on the Front Lines of Hospital Care Delivery

Our research identified two types of process failures—problems and errors. We define an *error* as the execution of a task that is either unnecessary or incorrectly carried out and that could have been avoided with appropriate distribution of pre-existing information. For example, we observed a patient who had been unnecessarily prepared for colonoscopy at significant expense to the hospital and discomfort to the patient before the specialist reviewed her case—revealing that the patient was not an appropriate candidate for the procedure—and cancelled it.

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Hospital errors have received considerable nationwide attention recently; however, an emphasis on only those errors that lead to severe consequences such as the death of a patient has perhaps obscured the subtler phenomenon of errors that take place within the care delivery process everyday—such as an unnecessary pre-operative preparation. Thankfully, most errors are caught and corrected before patients are harmed; however, a lack of attention to the process errors that precede more visible, consequential failures may limit opportunities for organizational learning.

The second type of failure is a *problem*, which we define as a disruption in a worker's ability to execute a prescribed task because either: something the worker needs is unavailable in the time, location, condition, or quantity desired and, hence, the task cannot be executed as planned; or something is present that should not be, interfering with the designated task.[6] Examples of problems include missing supplies, information, or medications. Unlike errors, work-process problems have received little attention in the literature or press. Like errors, problems are a valuable source of information about ways in which the system is not working.

Whereas workers can take action to solve problems, prevention of errors necessarily requires management involvement to redesign work systems.

Workers are well aware of the problems they encounter. In contrast, by definition, people are unaware of their own errors while making them. Not surprisingly, given that we observed the work processes from the viewpoint of front-line workers, the majority (86%) of the failures we observed in the care delivery process were problems rather than errors. Both kinds of failures require some kind of action for patient care to continue effectively. Whereas workers can take action to solve problems—due to their intense awareness of them—prevention of errors necessarily requires management involvement to redesign work systems in ways that make errors less likely to occur.

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First-Order Problem Solving

Research on quality improvement has distinguished between two types of response to problems—short-term remedies that "patch" problems and more thorough responses that seek to change underlying organizational routines to prevent recurrence.[14] We make a similar distinction between first- and second-order problem-solving behavior in service organizations.[15] First-order problem-solving behavior occurs when the worker compensates for a problem by getting the supplies or information needed to finish a task that was blocked or interrupted. The worker does not address underlying causes, thus not reducing the likelihood of a similar problem in the future. In our research, we found that nurses implemented a short-term fix for the overwhelming majority of the failures observed, enabling them to continue caring for their patients, without taking any action to try to prevent recurrence of similar failures—that is, without prompting organizational learning. For example, an oncology floor nurse who worked on the night shift ran out of clean linen to change her patients' beds. She walked to another unit that had linen in stock and took from their supply.

At first glance, first-order problem solving seems successful: the nurse was able to obtain linen. The cost to the nurse and to the hospital was minimal; it only took a few minutes of her time and was inexpensive. Notably, this nurse did not pay for a taxi to deliver the linen from an off-site linen cleaning service, which nurses at other hospitals reported as how they often handled the problem of running out of certain supplies, including linen. Seven out of nine nurses whom we interviewed reported feeling gratified when they figured out a way to work around an obstacle enabling them to continue patient care. The nurse missing linens commented,

> "Working around problems is just part of my job. By being able to get IV bags or whatever else I need, it enables me to do my job and to have a positive impact on a person's life—like being able to get them clean linen. And I am the kind of person who does not just get one set of linen, I will bring back several for the other nurses."

Upon further reflection, it appears that first-order problem solving can be counterproductive. It keeps communication of problems isolated so that they do not surface as learning opportunities. Workers rarely inform the person responsible for the problem, which prevents those people from learning that their processes could be improved. Sometimes, first-order problem solving creates new problems elsewhere, as when the above nurse took several sets of linens from another area. Moreover, considerable time (of highly paid professionals) is wasted on tasks and rework that would not otherwise be necessary. We found that, on average, 33 minutes were lost per eight-hour shift due to coping with system failures that could have been addressed and removed. Thus, first-order

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problem-solving behavior, ironically, can preclude improvement by obscuring the existence of problems and errors and preventing operational and structural changes that would prevent the same failures from happening again.

Our analysis identified two implicit strategies, or more colloquially, rules-of-thumb that exemplify first-order problem solving. The first rule of thumb is as follows: when you encounter a problem, do what it takes to continue the patient-care task—no more, no less. When nurses used this rule—which they did for 93% of the problems—their behavior involved securing the information or material they needed to do their jobs without probing into what caused the problem to occur. After the nurses were able to resume caring for the patient, they did not expend further effort on the incident; that is, they neither communicated that it occurred to others nor sought to investigate or change causes. This strategy served several purposes. It allowed a nurse to meet the requirements of the current patient—a responsibility that the nurses we observed did not take lightly. It also reduced the amount of time the harried nurse spends away from patient care duties; engaging in extra activity beyond the immediate fix would be a further drain on the care current patients received.

The second rule of thumb was—when necessary for continuity of patient care—to ask for help from people who were socially close rather than from those who were best equipped to correct the problem. The second rule of thumb helped to preserve the nurse's reputation regarding his or her competence at handling the daily rigors of nursing. In addition, it allowed nurses to avoid unpleasant encounters with cantankerous physicians or managers as long as possible. At the same time, it all but precluded addressing underlying causes that might improve the system. The nurses followed this rule for 42% of the problems and deviated from it for only 7% problems (e.g., they contacted a physician or other hospital personnel rather than attempting to solve the problem on their own).[16] The appeal and power of rules of thumb upon which one can tacitly rely in a time-pressured situation may help explain the high level of consistency of nurses' responses to problems.

Second-Order Problem Solving

Second-order problem-solving behavior occurs when the worker, in addition to patching the problem so that the immediate task at hand can be completed, also takes action to address underlying causes. Second-order problem solving includes: communicating to the person or department responsible for the problem; bringing it to managers' attention; sharing ideas about what caused the situation and how to prevent recurrence with someone in a position to implement changes; implementing changes; and verifying that changes have the desired effect. Given that nurses have so little spare time for extensive second-order problem-solving behavior such as tracking the problem to its source and making system changes to prevent recurrence, we categorized any behavior that called attention to the situation—thereby starting a legitimate process of inquiry into root cause which could then transpire over a period of time—as indicative of second-order problem-solving behavior. Nonetheless, only 7% of nurse responses met even these lenient criteria.

To illustrate second-order problem solving in this context, we observed an inexperienced intensive-care unit (ICU) nurse transfer a two-year old patient to the oncology floor by mistakenly leaving the sleeping child on his ICU bed rather than moving him onto the standard hospital bed in his new room, despite the protests of the oncology nurse that the highly-specialized ICU beds had to be returned. Not unexpectedly, the ICU nurse manager called the oncology unit secretary 30 minutes later, asking for the ICU bed. The oncology nurse—instead of simply returning the bed—did something that was unusual, and certainly not necessary for the immediate care of her patient. She called the ICU nurse manager, explaining, "I don't want to get anyone in trouble, but I want you to know what happened so you can talk to the nurse so that it does not happen again."

In this example, the nurse took care of the immediate situation—getting the ICU bed back to the unit—and *also* took action to try to remove the underlying cause of the error—the new ICU nurse's mistaken belief that it was worse to move a sleeping child than to leave an ICU bed on another unit. The ICU nurse manager could then ensure that all ICU nurses were aware of this requirement. The oncology nurse's apologetic introduction, when calling the ICU to engage in system-correcting behavior, is perhaps indicative of how counter-normative such behavior can be in hospitals. Instead of being governed by tacit rules-of-thumb that everyone seems to follow without explicit decision, second-order problem solving seemed to take conscious effort.

Second-order problem solving can have positive consequences for workers and the organization. If the worker's action is successful and the problem does not recur, they will not have to face similar obstacles in the future. As a result, second-order problem solving is a way that real change is achieved. The organization can benefit from higher productivity, customer satisfaction (because service is not interrupted), and worker satisfaction (feelings of competence from improving their work systems and less frustration with completing their tasks).

Three Positive Human Resource Attributes that Prevent Learning

Why aren't hospitals—and we suspect many other service organizations as well—learning all they can from daily problems encountered by their workers? Our research suggests that it is not because problems are highly complex or difficult to solve, nor is it because nurses are unmotivated—two plausible explanations. The problems we observed, while often requiring some sort of system change for resolution, were neither ill defined nor technically challenging. Instead, they were relatively straightforward and embedded in routine processes; typical examples included missing medications, regular-diet food trays being delivered for diabetic patients, insufficient supplies, and a lack of necessary medical orders for patient care.

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It is also not because nurses are uncommitted, lazy, or incompetent. The nurses studied were extremely dedicated and capable, often possessing advanced degrees and all had worked more than three years on their unit. Nine out of ten nurses whom we observed for an entire shift stayed an average of 45 minutes after their shift had ended—without extra pay—to complete their patient care duties. They ate their lunches in much less time than allotted and postponed taking personal breaks in order to provide the care they felt their patients deserved. One nurse, who worked from 7:00 A.M. until 7:00 P.M. called the unit at 4:00 A.M. after waking up, suddenly remembering something she had forgotten to tell the nurse who took over caring for her patients.

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The lack of organizational learning from failures can be explained instead by three less obvious, even counterintuitive, reasons: an emphasis on individual vigilance in health care, unit efficiency concerns, and empowerment (or a widely shared goal of developing units that can function without direct managerial assistance). These three factors, while seemingly beneficial for nurses and patients alike, can ironically leave nurses undersupported and overwhelmed in a system bound to have breakdowns because of the need to provide individualized treatments for patients.

First, individual vigilance—an industry norm that encourages nurses and other health care professionals to take personal responsibility to solve problems as they arise—is explicitly developed and highly valued in health care organizations. Counterintuitively, this can create barriers to organizational improvement because, in addition to encouraging individuals to be alert to things that can go wrong and to quickly take action, norms of individual vigilance encourage independence. Each caregiver thus tends to work on completing her or his own tasks without altering common underlying processes. Nurses are allowed, and even encouraged, to resolve problems independently without having to consider the impact on the system. In this way, problems of missing supplies or equipment tend to be resolved by taking the necessary items from somewhere else, hence creating another problem downstream. We found that nurses' problem-solving action tended to be directed at meeting immediate needs of patients; its scope rarely included assessing or remedying underlying causes—even when similar problems were confronted consecutively—making the chances of spurring organizational improvement and change through such efforts remote.

Second, nursing units were designed to maximize individual unit efficiency. Nursing labor is expensive and in short supply. Understandably, hospitals can ill afford to have nurses routinely working with slack resources. This staffing model leads to an organizational design where workers do not have time to resolve underlying causes of problems that arise in daily activities. Instead, nurses are barely able to keep up with the required responsibilities and are in essence forced to quickly patch problems so they can complete their immediate responsibilities. Thus, in this situation it is possible for an individual worker to be working non-stop while the content of the work technically adds little value to the customer's experience because of the amount of rework and unnecessary steps.

Third, empowerment of workers has been cited as a solution for quality and productivity problems.[17] The flip side of empowerment, however, is the removal of managers and other non-direct labor support from daily work activities, leaving workers on their own to resolve problems that may stem from parts of the organization with which they have limited interaction. Reducing the degree to which managers are available to front-line staff can be a loss for improvement efforts, especially when workers are already overburdened by existing duties. Managers tend to have a broader perspective than line workers, possess status necessary to resolve problems that cross organizational boundaries, and are capable of implementing solutions on a wider basis. This is not to say that nurses are not capable of engaging in such activities, but rather that the immediate nature of their duties precludes them from spending large amounts of time away from patient care. Without a readily available nurse manager, they are left without anyone to assist them in making these connections.

An Illusory Equilibrium Created by Responses to Process Failures

When a problem arises, a worker needs to engage in first-order problem solving merely to be able to continue his or her duties. First-order problem solving, however, does not alter the underlying conditions that gave rise to barriers to task completion, and so the failure, or one just like it, is likely to recur. This means that although the behavior appears to provide a solution, the solution, in fact, is a temporary measure. As a model of this dynamic phenomenon, Figure 1 depicts the causal relationships between these constructs.

The iterative relationship between problems (recognized by workers on the job as "barriers to task completion") and worker response (first-order problem-solving effort) is a dynamic structure of the type that researchers who study the dynamic properties of organizational systems have called a "balancing loop."[18] How it works is that the emergence of a problem (some disruption or barrier that would otherwise preclude the continuity of patient care) increases the chances (indicated by a plus sign in the thick arrow at the top of Figure 1) of a particular response—a first-order problem-solving effort. In turn, when this response successfully patches the problem, it reduces or removes the barrier (indicated by a minus sign next to the other thick arrow), allowing the caregiver to continue the patient care task.

This is a system in apparent balance. A problem shows up, action is taken, and the obstacle is gone—at least temporarily. As depicted in Figure 1, however, an increase in first-order problem solving actually *reduces* the likelihood that underlying causes will be addressed. First, the more effort expended in first-order problem solving, the less likely he or she is to have and take time to

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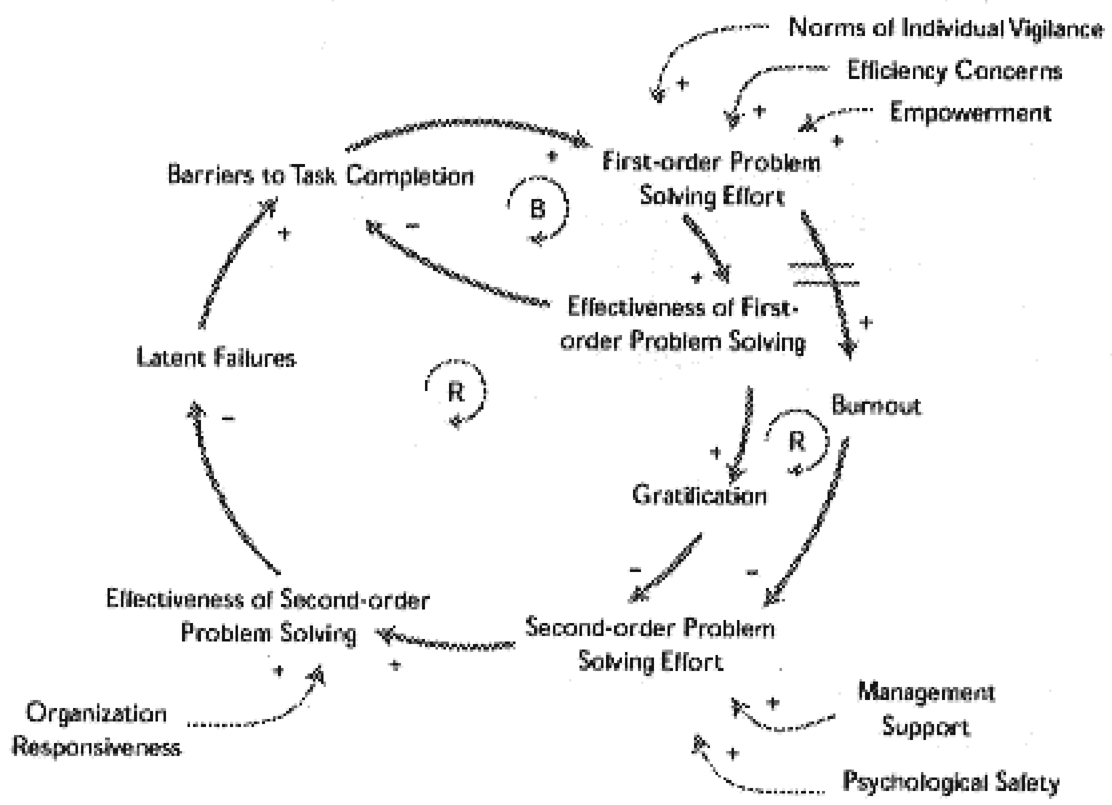
FIGURE 1. Model of First-Order and Second-Order Problem-Solving Behavior



engage in second-order problem-solving behavior. Because first-order problem solving takes time, it can leave workers with less flexibility to investigate causes and negotiate potential countermeasures.

A more subtle mechanism through which second-order problem-solving effort is reduced is the feelings of gratification that nurses report when effectively overcoming problems on their own. One nurse expressed her satisfaction when she was able to resolve issues that were preventing her from caring for her patients, "I have a lot of job satisfaction when I go home and I feel like I did everything that a patient needed and was entitled to. Even the little things." Ironically, this rewarding feeling of competence and self-sufficiency tends to further decrease the chances of expending effort to get others involved, as needed for second-order problem solving—and so the rate of failure emergence is not reduced. This is also depicted in Figure 1, in the positive link between effective first-order problem solving and worker feelings of gratification.

In most hospitals, organizational culture and management behaviors tend to reinforce this already-robust system of individual vigilance. Seventy percent of the nurses we interviewed commented that they believed their manager expected them to work through the daily disruptions on their own. Speaking up about a problem or asking for help was likely to be seen as a sign of incompetence. As one nurse interviewed explained, "My manager is not interested in hearing about things if they are small. If I went to her with a small problem, she would say, 'Solve it yourself.' To get any attention from managers, problems have to be something that is out of your hands—something you can't solve on your own."

Further, to those directly involved, things seem to be working reasonably well. It is stressful, but basically in balance. The catch is—because first-order problem solving is time-consuming and tiring—over time, burnout begins to take its toll on the system. This time delay is represented in Figure 1 by two slash marks between first-order problem-solving effort and burnout. This symbol indicates that first-order problem-solving behavior leads to burnout—but not immediately. Frustration and exhaustion accumulate over time. Not surprisingly, worker burnout then further decreases the chances of effortful engagement in second-order problem solving (another causal arrow marked by a minus sign in Figure 1). In addition, less effort on second-order problem solving means its effectiveness or ability to reduce latent failures also goes down. To illustrate this, in our study, one nurse said, "I am quite burned out as a whole with nursing. I would quit tomorrow if I could find decent work with health insurance—even for less pay."

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Over time, therefore, the apparent balance of this system is revealed as illusory. Workers experience an increasing sense of frustration, exhaustion and, in some cases, leave the organization—worn out by the task of swimming upstream against an incessant tide of small, annoying problems. Across the health care delivery industry, this phenomenon is contributing to unacceptably high levels of turnover in many organizations and to widespread nursing shortages.[19]

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一、

當你在評估衡量的工具時，信度(reliability)與效度(validity)相當重要，請回答下列相關問題：

1. 常用的信度衡量類型包括：(1) 穩定性(stability)；(2) 等值性(equivalence)；(3) 內部一致性(internal consistency)，請分別說明其意義？(15%)
2. 請問要如何提升研究的信度？(10%)
3. 請說明內容效度(content validity)、效標關聯效度(criterion-related validity)與構念效度(construct validity)的意義？(15%)
4. 請問要如何提升研究的效度？(10%)

二、有些研究會被批評爲不「嚴謹」，請依社會科學研究過程中的各事項(從問題定義到研究結果之意涵的討論)，來說明何謂「嚴謹」的研究？(30%)
並在每一事項上舉例說明「嚴謹」與「不嚴謹」的差別。(20%)